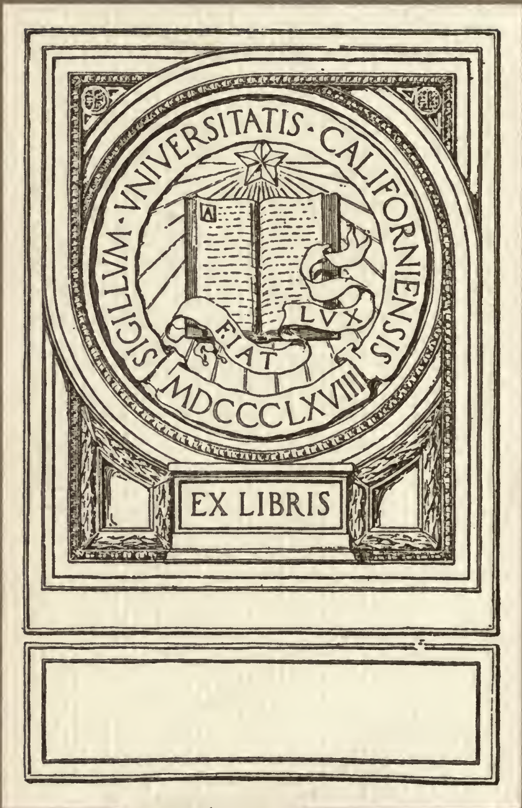
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American Coals

THEIR ORIGIN
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"COAL in truth stands not beside but entirely above all other commodities. It is the material energy of the country—the universal aid—the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times."

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THE STORY

OF

AMERICAN COALS

BY

WILLIAM JASPER NICOLLS
M. Am. Soc. C.E.

AUTHOR OF "THE RAILWAY BUILDER," "COAL CATECHISM," ETC.

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To

J. O. N.

146018

PREFACE TO THE SECOND EDITION

This Second Edition has been carefully revised and brought up to date. Since the first was issued the United States has passed from second place in coal production to the head of all other nations. From this important position it can never be removed.

W. J. N.

Philadelphia, 1904.

PREFACE TO THE FIRST EDITION

PRIMARILY, this work is designed for those who wish to be informed on the subject of Coal, without referring to other publications, now widely scattered, and many out of print.

The simple arrangement of the chapters, beginning with the origin of coal, and its development, together with a description of the different routes by which it reaches the consumer, and the various uses to which it is put, is followed by a complete index, so that the book can be used for reference.

It treats only of American Coals—a subject of such importance as to reach the enormous total in value of nearly two hundred millions of dollars annually.

During fifteen years of employment in the coal-fields of Pennsylvania, the writer has gathered the material from every available source, and added it to his practical knowledge gained by experience. With this, the "Story" has been written for those interested in American Coals, either as operators, miners, dealers, carriers, or the multitude of consumers—the American people.

W. J. N.

PHILADELPHIA, 1896.

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PART I

ORIGIN

THE STORY OF AMERICAN COALS

CHAPTER I.

THEORIES.

The age of the earth has long been a subject of much ingenious speculation by men of science and theology, and many theories have been advanced —more or less interesting—to solve this much-discussed question. It has been accurately determined, at least to one author's satisfaction, by the various deposits of rock in the bed of the Nile. By another it has been solved with equal exactness by the face of the rocks cropping out along the hoary cliffs of some denuded mountain-chain. While another, quite as positive, calculates to a certainty, by the degrees of heat contained in its interior, the time required to form its surface.

Most of them agree that America is of much greater antiquity than that portion of the globe we designate the old world. When vast seas swept over what is now the land, the whole backbone of our country—the coast line of the Pacific—in

North and South America, was elevated above the waters when a large portion of the old world was submerged. The action of the waters rounded the fragments of volcanic rock, and washed them into great beds of conglomerate rock and sandstone. Upon these beds, or basins, was accumulated the vegetable matter which, rotting and settling for ages, became the marvellous storehouses of coal from which we draw our supplies.

Bowen locates these basins as follows:

"There is a small basin running from the Rio Grande River, in the southern part of Texas, northeast to the Red River. This basin at one time received the waters of both these streams, besides those of the upper Colorado and Brazos, which now pass through it to the Gulf of Mexico. Coal is found at both ends of it, and when it was finally elevated its waters were discharged in the rivers now flowing through and around it.

"Another basin is traversed by the Arkansas River, farther east, and lying in the State thus named.

"Another, larger and better defined than either, occurs in Iowa and Missouri, into which the Missouri River originally emptied, and through the western boundary of which it now passes.

"A fourth basin, still larger and better defined, is in the State of Illinois, the capital of the State being very near its centre. This great basin received the waters of the Missouri, those of the upper Mississippi, of the river Illinois, of the Ohio, the Tennessee, and many other smaller ones. It was a great basin and considerably larger than our existing Lake Superior.

"Farther north, bounded on the west by the entire length of Lake Michigan, and on the northeast by Lake Huron, is a fifth basin, not so large or well defined as the last mentioned, but indicating, from its proximity to the existing lakes, their former extension over the Devonian (Old Red Sandstone) rocks that are now intermediate between them.

"The last and by far the largest basin is that comprising the Allegheny Mountains, beginning in the southwest on the head-waters of the Mobile River, in the State of Alabama, and in the northwest on the Tennessee River—very nearly adjoining the Illinois basin—and thence running northeast with the Allegheny Mountains through Kentucky, Virginia, Maryland, and Pennsylvania, and finally terminating in a broad expanse in the State of New York.

"A sixth, but very small basin, occurs in Rhode Island, connected with the sea by a broad inlet."

How these basins became filled with the great deposits of coal is still a matter of pure conjecture, and will remain so until the end of time.

One authority surmises that of the coniferous trees, the resinous juices only—expelled from the interior woody cells of the trees—constituted the matter which, first in a soft and viscid condition, like tar, afterwards became hard and brittle. He supports this theory from the fossil remains of trees, which are generally found compressed or flattened out, as though under a heavy weight, and that none of the trees are actually converted into coal, but are found embedded *in* it.

Another inclines to the Peat-bog theory; that is, a supposititious wide-spreading marsh, interspersed by numerous streams of water from a river or the arms of an ocean. Upon these marshes grew luxuriant vegetation of the Carboniferous age—the calamites, sphenopteris, sigillaria, stigmaria, etc.—which fell into the waters of the marsh. When this matter had accumulated the marsh was overflowed by the ocean, which deposited a layer of mud and silt upon the soft, rotting vegetable mass, and by its weight resolved it into coal. The water receding, another marsh was formed, with growing vegetation, as before.

"The most plausible and reasonable theory of the formation of coal," says L. Simonin, the French engineer, "seems to be that it is for the most part the remains of vegetable matter, which became decomposed and mineralized on the spot where it grew and is now found.

"The fibrous tissue of the aquatic vegetation, which flourished as a thick carpet at the feet of the larger plants, mingled and became matted together, as is the case now with the turf and peat of most peat bogs, forming swamps and marshy plains; only at the period in question the phenomenon was more general than at the present day, and occurred on an enormous scale—on the borders of great lakes and estuaries; that is to say, where the fresh water of rivers first mingled with the salt water of the sea. Vast lagoons were thus formed, as is still seen, only on a smaller scale, beneath the tropics, in Senegal and Madagascar. In these lagoons vegetation must have been developed with the greatest luxuriance and profusion.

"These wide, swampy or peaty plains occupied portions of the earth's surface which, owing to subterranean movements, were undergoing slow depressions. Hence, by degrees the layer of matted vegetation was carried down beneath the level of the sea, which then flowed over it and deposited above it those layers of sand, silt, and mud which we now find among and alternating with our coal seams as beds of sandstone and shale. The downward movement, however, was not constant. It seems to have been intermittent, or interrupted by minor elevations, or by long pauses, during which the accumulating sediment filled up the lagoons and allowed new jungles to spring up and marshy tracts to be formed. As the submergence recommenced these were in like manner entombed beneath the silt of the encroaching waters.

"Thus, stage by stage, the vast pile of strata known as the Coal Measures was built up."

If we suppose this theory to be correct, then we must conceive the whole Appalachian territory to have been one vast level marsh, with a period of fifteen hundred to two thousand years to have formed the bituminous beds of the Alleghenies; this period to have been one of repose, alternating with violent discharges of volcanic matter, for the necessary material to form the intervening strata of sandstone, fire-clay, shale, etc., or the slower process of deposition made by the invading sea at each subsidence of the earth.

Many authorities support the Estuary or Drift theory; that is, that the vegetation was carried or drifted down the rivers, and deposited in successive layers at their mouths, or junction with the great inland seas.

"What must be the fossil contents of a basin or valley into which some partial deluge should sweep one of the immeasurable forest tracts of North or South America! There are accumulations of driftwood taking place on some of the rivers on that quarter of the globe which, whether destined to become coal strata, as some think, or otherwise, may, at some remotely future period, when the land will perhaps be comparatively denuded, and other changes have taken place, present a problem of almost as disputable, if not difficult, a solution as that of the formation of the existing coal-fields."

"In the spring, or rather winter," says Captain Hall, "when the freshets or floods come down the Mississippi, they bring with them millions of trunks of trees technically called logs. In February or March the quantity of these logs is sometimes so great that not only the river itself, but the sea for several miles off, was so completely covered over with them that it required some skill to get through. The whole ground—if the loose and muddy soil could be so called—appeared to be formed of layers of these logs, matted together into a net-work, or rather a gigantic raft, of rough timbers, many yards and perhaps fathoms in depth, over hundreds of square leagues.

"May not this stratum of vegetable matter, which there is every reason to suppose stretches over the whole delta at the level of the sea, become in some future geological revolution in the world a great coal-field?"

Some years ago Professor Bakewell wrote as follows:

"What is called the Valley of the Mississippi is not in reality a valley, but an extensive elevated plain without hills or inequalities deserving attention. It extends west from the western slope of the Allegheny Mountains to the sand plains near the Missouri, a distance of about 1500 miles, and south from the valley of the northern lakes to the mouth of the Ohio, about 600 miles.

"No part of the globe possesses such an extent of uniform fertility. The difference in elevation is only a few feet, as ascertained by actual survey. The general elevation of this plain is about 800 feet above the sea. It is crossed by the great rivers Missouri, Mississippi, Ohio, and their branches. As we go westerly up the Missouri and Arkansas to the sand plains we find the same elevation. The great and numerous rivers that cross this plain instead of forming valleys do but indent narrow lines or grooves in its surface, hardly sufficient to retain their floods. As the currents of these rivers roll on in their courses, they sink deeper into the plain; hence the large rivers Ohio, Missouri, and others seem bordered with hills of several hundred feet elevation towards their mouths; but the tops of these hills are the level of the great plain.

"The base of this whole extent of plain appears to be transition or mountain limestone, in nearly horizontal beds; it has been perforated to the depths of 400 and 600 feet. It contains trilobites, orthoceratites, the productus, and other fossils that characterize the transition limestone. The uppermost stratum of limestone is not many feet below the surface, and supports, over nearly its whole extent, strata of bituminous coal and saline impregnations. The limestone extends under the Allegheny Mountains in the east, and the sand plains on the west, and rests on the granite ridges of Canada on the north. This coal-field would cover half Europe, having an extent of 900,000 square miles; or 1500 miles in length by 600 miles in breadth.

"In the geological position and physical structure of this vast coal-field we may, I think, trace in a satisfactory manner the mode of its formation. Were the outlet of the waters that drain this large surface to be only partially closed (as we may suppose the mouth of the Mississippi to be) by an earthquake or upheaving of the surface, then in the time of annual periodical inundations the whole extent of this level plain would be covered with fresh water and form an inland sea, which would gradually become dry as the inundations subsided. This plain would then become a vast swamp, suited for the rapid development of vegetation. In this manner thick beds of decomposed vegetable matter might every year be formed, and subsequently be covered with strata of mud and earthy matter, deposited during the inundation.

"Now let us advert to what actually takes place in the lower valley, or plain, of the Mississippi every year.

"When those mighty rivers, the Mississippi and Missouri, are inundated by the melting of the snow near their sources, they pour down immense floods, which fill the banks and absolutely choke up the mouths of the large secondary rivers that enter them and throw their waters back for many miles, charged with the mud and the great descending waters. The waters of these secondary rivers in their backward course overflow their banks and spread over the lower part of the level plain, forming lakes of twenty miles or more in length; after some time these lakes are gradually drained by the subsidence of the rivers. The inundations are, however, prolonged by another circumstance. The Missouri and Mississippi rise in different latitudes, and their periodical inundations do not take place at the same time. When one of these mighty streams is inundated, it blocks up the passage of the other, and this reacts on the secondary streams and prolongs the time of periodical inundation. Thus, in these temporary lakes of fresh water, we have the conditions required for the foundation of future coal-fields—swamps promoting the rapid development and decomposition of vegetables—and periodical inundation of water, charged with sand and mud, to cover the vegetable beds with earthy strata. It is further deserving notice that over a large part of the plain of the Mississippi the rapid annual growth of grasses and weeds exceeds anything of which Europe affords an example. This enormous mass of vegetation perishes every winter."

A writer in *Longman's Magazine* says:

"The Mississippi has, in the course of ages, transported from the mountains and high lands, within its drainage area, sufficient material to make 400,000 square miles of new land by filling up an estuary which extended from its original outfall to the Gulf of Mexico, for a length of 500 miles, and in width from 30 to 40 miles. The river is still pouring solid matter into the Gulf, where it is spread out in a fan-like shape over a coast line of 159 miles and is filling up at the rate of 362,000,000 tons a year, or six times as much soil as was removed in the construction of the Manchester, England, ship-canal, and sufficient to make a square mile of new land, allowing for its having to fill up the Gulf to a depth of 80 yards.

"Some idea of the vastness of this operation may be conceived when the fact is considered that some of this soil has to be transported more than 3000 miles, and that if the whole of it had to be carried in boats, at the lowest rate at which heavy material is carried on the inland waters of America, or say, for one-tenth of a penny per ton per mile, over an average of half the total distance, the cost would be no less a sum than £238,000,000 a year.

"Through the vast delta thus formed the river winds its way, twisting and turning by innumerable bends until it extends its length to nearly 1200 miles, or more than double the point-to-point length of the delta, continually eroding the banks in one place and building up land in another, occasionally breaking its way across the narrow neck which lies between the two extremities and filling up the old channel."

Such is a notable present-day example of the Estuary or Drift theory.

CHAPTER II.

GEOLOGY.

All theories agree that the period of coal formation was prior to the creation of man. They suppose a world surrounded with heavy carbonic acid gas, unfit for human lungs; its crust fissured and cracked with gaping exits for volumes of vaporous gases from the fiery interior and the surrounding waters. In this congenial atmosphere vegetation flourished and grew with rank profusion. The calamites, with stems like great corn stalks, from two to three feet in diameter, towered forty to fifty feet above the mass of huge ferns of the dark morass. The common horse-tails, now found in ponds and river-banks, here grew into trees. The Lepidodendron, or scaly tree, from its resemblance to the scales of a fish, or the Sigillaria, with the deeply furrowed bark, and scars at regular intervals, like the stamp of a seal in wax, —who would recognize in their giant forms the common yellow pine or club-mosses of to-day!

Let us stand with Hugh Miller, the geologist, and imagine a low shore thickly covered with vegetation.

"High trees of wonderful form stand far out into the water. There seems no intervening beach. A thick hedge of reeds, tall as the masts of pinnaces, runs along the deeper bays like water flags at the edge of a lake. A river of vast volume comes rolling from the interior, darkening the water for leagues with its slime and mud, and bearing with it to the open sea reeds and fern and cones of pine, and immense floats of leaves, and now and then some bulky tree, undermined and uprooted by the current.

"We near the coast and now enter the opening of the stream.

"A scarce penetrable phalanx of reeds that attain to the height, and well-nigh the bulk, of forest trees is ranged on either hand. The bright and glossy stems seem rodded like Gothic columns, the pointed leaves stand out green at every joint,—tier above tier,—each tier resembling a coral wreath or an ancient crown, with the rays turned outward; and we see atop what may be either large spikes or catkins.

"What strange forms of vegetable life appear in the forest behind!

"Can this be club-moss that raises its slender height for more than fifty feet from the soil?

"Or can these tall, palm-like trees be actual ferns, and these spreading branches mere fronds?

"And then these gigantic reeds! Are they not mere varieties of the common horse-tails of our bogs and morasses, magnified some sixty or a hundred times? Have we arrived at some such continent as the country visited by Gulliver, in which he found thickets of weeds and grass tall as woods of twenty years' growth, and lost himself amid a forest of corn fifty feet in height?

"The lesser vegetation of our own country, its reeds, mosses, and ferns, seem here as if viewed through a microscope; the dwarfs have sprung into giants, and yet there appears to be no proportional increase in size among what are unequivocally its trees.

"Yonder is a group of what seem to be pines, tall and bulky it is true, but neither taller nor bulkier than the pines of Norway or America; and the club-moss behind shoots up green, hairy arms, loaded with what seem catkins, above their topmost cones.

"But what monster of the vegetable world comes floating down the stream, now circling round in eddies, now dancing on the ripple, now shooting down the rapid?

"It resembles a gigantic star-fish or an immense coach-wheel divested of its rim. There is a green dome-like mass in the centre, that corresponds with the nave in the wheel, or the body of the star-fish; and the boughs shoot out horizontally on every side, like the spokes of the nave, or rays from the central body.

"The diameter considerably exceeds forty feet; the branches, originally of deep green, are assuming the golden tinge of decay; the cylindrical and hollow leaves stand out thick on every side, like prickles on the wild rose, on the red, fleshy, lance-like shoots of a year's growth, that will be covered two seasons hence with flowers and fruits. That strangely formed organism presents no existing type among all the numerous families of the vegetable kingdom.

"There is an amazing luxuriance of growth all around us. Scarce can the current make its way through the thickets of aquatic plants that rise thick from the muddy bottom; and though the sunshine falls bright on the upper boughs of the tangled forest beyond, not a ray penetrates the more than twilight gloom that broods over the marshy surface below.

"The rank stream of decaying vegetation forms a thick blue haze that partially obscures the underwood. Deadly lakes of carbonic acid gas have accumulated in all the hollows. There is a silence all around, uninterrupted save by the sudden splash of some reptile fish that has risen to the surface in pursuit of his prey, or when a sudden breeze stirs the hot air and shakes the fronds of the giant ferns, or the catkins of the reeds.

"The wide continent before us is a continent devoid of animal life, save that its pools and rivers abound in fish and mollusca, and millions and tens of millions of the infusoria tribes swarm in the bogs and marshes.

"Here and there, too, an insect of strange form flutters among the leaves.

"It is more than probable that no creature furnished with lungs of the more perfect construction could have breathed the atmosphere of this early period and have lived."

The mud on the bottom of these great coal-forming seas is the fire-clay of our times. From this bed sprung the huge ferns and gigantic trees, which flourished to an unprecedented degree during a season of what must have been perpetual summer; a continual blaze of tropical heat and sunshine, of warm vapors and dense humidity, producing a growth of rank, sappy vines and sticky, resinous, enormous weeds in a much shorter time than many geologists would have us believe.

To the mind of the careful student of the coal formation it becomes evident that the Carboniferous period need not have been of great duration to produce the necessary matter for the formation of coal under such favorable conditions as then existed.

Many years ago James Hutton published a work, "A Theory of the Earth," in which he states that the earth was once the sea, and that the sea will again be the earth; that the formation of coal strata was due to the immense amount of smoke thrown off from the active volcanoes and from other sources and duly precipitated as sediment in the bottom of the sea; that this included the floating oils and bitumen from the large rivers flowing into the sea; that the sea then became land from its gradual filling up, and that the land subsided and became the sea. The mind wearies with the effort to imagine the length of time necessary to accomplish this terrestrial revolution—to arrive at the end of the process. But the author collects our tired gropings and, guiding us around a circle, leaves us to pursue our monotonous course:

"Our solid earth is everywhere wasted, where exposed to the day. The summits of the mountains are necessarily degraded. The solid and weighty materials of those mountains are everywhere urged through the valleys by the force of running water. The soil, which is produced in the destruction of the solid earth, is gradually travelled by the moving water, but is constantly supplying vegetation with its necessary aid. This travelled soil is at last deposited upon the coast, where it forms most fertile countries. But the billows of the ocean agitate the loose materials upon the shore and wear away the coast with the endless repetition of this act of power on this imparted force. Thus the continent of our earth, sapped in its foundation, is carried away into the deep, and sunk again at the bottom of the sea, from whence it had originated.

"We are thus led to see a circulation in the matter of this globe and a system of beautiful economy in the works of nature. This earth, like the body of an animal, is wasted at the same time that it is repaired.

"It has a state of growth and augmentation; it has another state, which is that of diminution and decay.

"This world is destroyed in one part, but it is renewed in another, and the operations by which this world is thus constantly renewed are as evident to the scientific eye as are those in which it is necessarily destroyed."

No one who has ever studied the locations of the various coal basins in this country can have failed to notice the peculiar similarity of the parallel ranges of mountains in their course northeast and southwest, and almost directly across the direction of the various rivers flowing to the sea.

Volney, the French traveller, writes in 1804:

"Even in the present day the Mississippi exhibits to us an instructive spectacle of all these grand operations. It is calculated by Liancourt that in the space of fourscore years, from 1720 to 1800, it has encroached upon the sea about fifteen miles; thus under the eyes of three generations it has created at its mouth a new country, which it increases every day, and in which it lays up beds of coal for future ages. Such is the celerity of its accumulative process, that at New Orleans, a hundred miles above its present mouth, a canal lately cut by the governor, Baron Carondelet, from the river to Lake Pontchartrain, has brought to view an interior bed of earth formed entirely of black mud and trunks of trees, heaped together several feet deep, which have not yet had time either to rot or to be converted into coal. Both banks of the river wholly consist of trunks of trees thus agglutinated by mud for a space of more than three hundred miles; and the waters have heaped them up to such a height that they form a mound on each side from twelve to sixteen feet higher than the adjacent land, which is generally lower; and at the annual rise of the river, which is about twenty-four feet, the exuberant water being unable to re-enter the channel, forms vast and numerous marshes, which will some day become the source of wealth, but are at present an obstacle to agriculture and population.'' The same author speaks of the ancient lakes in the United States, which have disappeared. ''In the structure of the mountains of the United States another circumstance exists, more striking than in any other part of the world, which must singularly have increased the action and varied the movements of the waters.

''If we attentively examine the land, or even the maps of the country, we must perceive that the principal chains or ridges of the Alleghenies, Blue Ridge, etc., all run in a transverse direction to the course of the great rivers; and that these rivers have been forced to rupture their bonds and break through these ridges in order to make their way to the sea from the bosom of the valleys.

''This is evident in the rivers James, Potomac, Susquehanna, Delaware, etc., when they issue from the confines of the mountains to enter into the lower country.

''The ancient lakes explain why, in every part of the basin of the Ohio, the land is always levelled in horizontal beds of different heights, why these beds are placed in the order of their specific gravity, and why we find in various places remains of trees, of osiers, of plants, and even of animals, as the bones of mammoths in heaps among others, at the place called Bigbone Licks, thirty-six miles above the river Kentucky, and which could not have been thus collected together except by the action of water. Lastly, they, as happily as naturally, account for the formation of the beds of coal, which are found principally in certain situations and in particular districts.

"In fact, from the researches which the industry of the inhabitants has made more frequent within these twenty years, it appears that the principal seat of coal is above Pittsburgh, in the space between the Laurel Mountain and the rivers Allegheny and Monongahela, where there exists almost throughout a stratum, at the mean depth of twelve or sixteen feet. This stratum is supported by the horizontal bed of calcareous stones and covered with strata of schist and slate; it rises and falls with these on the hills and in the valleys, and it is thicker in the former, thinner in the latter, being in general from six to seven feet. On considering its local situation, we see it occupies the lower basin of the two rivers I have mentioned, and of their branches, the Yohoghany and Kiskiminitas, all of which flow through a nearly flat country into the Ohio, below Pittsburgh.

"Now, on the hypothesis of the great lake of which I have spoken, this part will be found to have been originally the lower extremity of the lake, and the part where its being kept back would have occasioned still water. It is admitted by natural philosophers that coal is formed of heaps of trees carried away by rivers and floods, and afterwards covered with earth. These heaps are not accumulated in the course of the stream, but in parts of it, where they are left to their own weight. This process may be observed even now in many rivers of the United States, particularly in the Mississippi, which, as I have said, annually carries along with it a great number of trees.

"Some of these trees are deposited in the creeks or bays, into which they are carried by the eddies, and there left in still water; but the greater part of them reach the borders of the ocean, where, the current being balanced by the tide, they are rendered stationary and buried under the mud and sand by the double action of the stream of the river and the reflux of the sea. In the same manner, anciently, the rivers that flow from the Allegheny and Laurel Mountains into the basin of the Ohio, finding towards Pittsburgh the dead waters and tail of the great lake, there deposited the trees, which they still carry away by thousands when the frost breaks up and the snows melt in the spring. These trees were accumulated in strata level as the fluid that bore them; and the mound of the lake sinking gradually, as I explained, its tail was likewise lowered by degrees, and the place of deposit changed, as it changed forming that vast bed which in the lapse of ages has been subsequently covered with earth and gravel and acquired the state in which we see it. Did we know the length of time requisite for converting trees, buried under such circumstances, into coal, these operations of nature would form chronological tables of far superior authority to the dreams of visionaries among a barbarous and superstitious people.

"Coal is found in several other parts of the United States, and always in circumstances analogous to those I have just described. It is possible that veins or mines of coal not adapted to this theory may be mentioned or discovered on the Atlantic coast. But one or more such instances will not be sufficient to subvert it, for the whole of this coast, or the land between the ocean and the Alleghenies, from the St. Lawrence to the West Indies, has been deranged by earthquakes, the traces of which are everywhere to be seen; and these earthquakes have altered and nearly destroyed the regular horizontal arrangement of the strata throughout the whole of this space."

A recent writer speaks of the Delaware River, which, "In its course, hugs the base of the grand old mountains—older in date of upheaval than the snow-clad Alps—which once formed a barrier to its passage and rolled back the flood of waters, submerging for a long time the lesser hills and swelling plains that, now clad in verdure, adorn its borders."

It is not difficult for a summer visitor to the summit of Mount Pocono, gazing on the distant hills and the break in their continuity occasioned by the famous Delaware Water Gap, to imagine the plains in the foreground, covered with the waters of a lake, kept back by the long range of mountains which exactly resemble the breast of a dam. That the waters broke through the visible gap is also highly probable.

In "American Antiquities," by Priest, the prediction is made that Niagara Falls—having already receded some seven or eight miles—might at any time start a brisk retrograde movement, facilitated by an earthquake, and move back, quite up to Lake Erie, causing the water of that inland sea to descend precipitately upon the lower countries in its way to the ocean. Other authors mention this possibility, but add a few figures, by way of comment, based on the rate of progress thus far made. The distance is something less than twenty-five miles, and the retrograde movement about a foot a year, so that, this rate of progress being continued, it would take something like 132,000 years to reach the lake!

It is possible, but not at all probable, that a sudden catastrophe might rend the rocks and hasten the evil day when New York and Pennsylvania would be swept by a deluge of water from the lakes, which in its awful effects can scarcely be imagined.

And whether such events have happened in the great immensity we call the Past; whether the great inland seas of the geologists ever burst their barriers through the Alleghenies, destroying in the wild rushing of waters every living thing in their destructive paths; whether the noble seams of coal traversing our grand continent, from northeast to southwest, were deposited in marshland or valleys, oceans or seas, rivers or ponds, need not concern us in our efforts to develop the immense treasure the Almighty has so generously supplied to us and for our use.

CHAPTER III.

EARLY MENTION.

The earliest mention made of coal is contained in the Bible—Prov. xxvi. 21:—"As coals are to burning coals, and wood to fire, so is a contentious man to kindle strife." This was written about B.C. 1016.

While the word "coal" here used may denote wood, charcoal, or any substance used as fuel, there appears to be good reasons for supposing that it means the plain black bituminous coal of the present day taken from the underlying seams in the earth.

Solomon counted among his domains all Syria, at least from 1016 B.C., the time he began to reign, until 980 B.C., when part of it was taken from him by Rezon, a native of Zobah (1 Kings xi. 23–25), who took from him Damascus, and Syria includes bituminous coal among its mineral productions to-day. The sandstone formations of Hermon and Lebanon are full of fossils of the Carboniferous era, and in the neighborhood of the Dead Sea are bituminous or bitumen pits, evidently of the same origin. Iron is also found here and some quicksilver. That Solomon was familiar with the product of which he speaks so plainly seems to be a reasonable conclusion.

Assuming this to be the case, the frequent mention of coal in the Bible becomes easy of construction. The next mention we have of it is in Isaiah xlvii. 14: "There shall not be a coal to warm at, nor fire to sit before it," written probably about 752 B.C., and referring to God's judgment upon Babylon and Chaldea. Again, Isaiah xliv. 12: "The smith with the tongs both worketh in the coals, and fashioneth it with hammers, and worketh it with the strength of his arms," contains no ambiguity, if taken literally. Or in Isaiah liv. 16: "I have created the smith that bloweth the coals in the fire."

The next mention occurs in the Lamentations iv. 8: "Their visage is blacker than a coal," written probably about 625 B.C.

The next mention we have of coal occurs in the writings of Theophrastus, the divine speaker, orator, and friend of Aristotle, the Greek, as follows:

"Those substances that are called coals and are broken for use are earthy, but they kindle and burn like wooden coals. They are found in Lyguria, where there is amber, and in Elis, over the mountains toward Olympias. They are used by the smiths." This was written about 334 B.C., or four hundred years before the next mention of coal in the Bible, by John the Apostle, in his Gospel, xviii. 18, as follows:

"And the servants and officers stood there, who had made a fire of coals; for it was cold: and they warmed themselves: and Peter stood with them, and warmed himself."

Evidences are found in the discovery of tools and coal cinders near the ancient Roman wall that in England coal was used by the Britons prior to the Roman invasion (54 B.C.), but the first actual record of coal being used in England is a receipt of twelve cart-loads by the Abbey of Petersboro, A.D. 852. The first record of actual mining operations is in the books of the Bishop of Durham, 1180.

Coal was employed years before the Christian era in China, and probably in very ancient times, if the accessible deposits in Shensi then cropped out in the eroded gorges, as represented by Richthofen.

The mode of working these mines is described by Pumpelly, and was probably no worse 2500 years ago.

"Want of machinery for draining them prevents the miners from going much below water level, and a rain-storm will sometimes flood and ruin a shaft. An inclined plane seldom takes the workman more than a hundred feet below the level of the mouth, and then a horizontal gallery conducts him to the end of the mine. Some water is bailed out by buckets, handed from one level up to another, at the top. The coal is carried out in baskets on the miners' backs, or dragged in sleds over smooth, round sticks along low passageways."

Blakiston gives an account of the manner in which coal is worked on the Upper Yangtsi, near the town of Suchan: "Having to be got out at a great height up in the cliff, very thick hawsers made of plaited bamboo are tightly stretched from the mouth, or near the mouth, of the working gallery, to a space near the water where the coal can be deposited. These ropes are in pairs, and large pannier-shaped baskets are made to traverse on them, a rope passing from one over a large wheel at the upper landing and down again to the other, so that the full bucket going down pulls the empty one up, the velocity being regulated by a kind of brake on the wheel at the top. At some places the height at which the coal is worked is so great that two or more of the contrivances are used, one taking to a landing half-way down and another from thence to the river. The hawsers are kept taut by a windlass for that purpose at the bottom."

"With such inexpensive methods of getting coal to the water-courses," says Williams in "The Middle Kingdom," "foreign machinery can hardly be expected to reduce its price very materially. Coal sells in China from 50 cents to $2.00 per ton, depending in a great measure on the cost of timbering. The mines lying on the slopes of the plateau, reaching from near Corea to the Yellow River, supply the plain with cheap and excellent fuel. The economical use of coal in the household and the arts has been carried to great perfection in China, and must have continued for ages past. Anthracite is powdered and mixed with wet clay, earth, sawdust, or dung, according to the exigencies of the case, in the proportion of about 7 to 1; the balls thus made are dried in the sun.

"The hand furnaces enable the poor to cook with these balls at a trifling expense. Bituminous, brown, and other varieties of coal occur in great abundance in China, giving promise of adequate supplies for future ages."

In 1275, Marco Polo, a Venetian traveller, wrote as follows: "It is a fact that all over the country of Cathay there is a kind of black stone existing in beds in the mountains, which they dig out and burn like fire-wood. It is true they have plenty of wood also, but they do not burn it, because those stones burn better and cost less."

His countrymen did not believe him.

The first shipment of coal to London was made in 1240; and the first successful effort made to smelt ore with coal in a blast furnace was by one Simon Sturtevant, an Englishman, in 1612. The earliest historic mention of coal in our country is by the French Jesuit missionary, Father Hennepin, who saw traces of bituminous coal on the banks of the Illinois River in 1679. In his journal he marks the site of a "cole mine" above Fort Crecolur, near the present town of Ottawa.

In 1750 the Virginia bituminous mines were opened and worked on the James River, near Richmond. Some years ago Sir Charles Lyell, the eminent English geologist, visited these mines and writes of them as follows:

"I had stopped at Richmond on my way south, for the sake of exploring geologically some coal-mines, distant about thirteen miles from the city to the westward. Some of the largest and most productive of these, situated in Chesterfield County, belong to an English company, and one of them was under the management of a former officer in the British army.

"There are two regions in the State of Virginia —a country about equal in area to the whole of England—in which productive coal-measures appear. In one of these, which may be called the western coal-field, the strata belong to the ancient carboniferous group, characterized by fossil plants of the same genera and to a great extent the same species as those found in the ancient coal-measures of Europe. The other one, wholly disconnected in its geographical and geological relation, is found in the east of the Appalachian Mountains, in the middle of that gigantic region sometimes called the Atlantic Slope. In consequence of the isolated position of these eastern coal-beds, the lowest of which rest immediately on the fundamental granite, while the uppermost are not covered by any overlying fossiliferous formations, we have scarcely any means of determining their relative age, except by the characters of their included organic remains. The study of these induced Professor W. B. Rogers, in his memoir, published in 1842, to declare his opinion that this coal was of newer date than that of the Appalachians, and was about the age of the Oolite or Lias, a conclusion which, after a careful examination of the evidence on the spot and of all the organic remains which I could collect, appears to me to come very near the truth. If we embrace his conclusion, these rocks are the only ones hitherto known in the Canadas and the United States, which we can prove, by their organic remains, to be of contemporaneous origin with the Oolitic or

Jurassic formation of Europe. The tract of country occupied by the crystalline rocks, granite, gneiss, hornblende schist, and others, which runs parallel to the Allegheny Mountains and between them and the sea, is in this part of Virginia about seventy miles broad. In the midst of this area occur the coal-fields alluded to, twenty-six miles long and varying in breadth from four to twelve.

"The James River flows through the middle of it, about fifteen miles from its northern extremity, while the Appomattox River traverses it near its southern border.

"The beds lie in a trough, the lowest of them usually highly inclined, where they crop out along the margin of the basin. The coal, for the most part, is very pure, and actually attains the unusual thickness of between thirty and forty feet. I was not a little surprised when I descended a shaft of 800 feet deep to find myself in a chamber more than forty feet high, caused by the removal of the coal. Timber props of great strength are required to support the roof, and although the use of wood is lavish here, as in most parts of the United States, the strong props are seen to bend under the incumbent weight.

"By analysis it is found that, so far as relates to the proportions of carbon and hydrogen, the composition of this coal is identical with that of ordinary specimens of the most ancient coal of Europe and America, although the former has been derived from an assemblage of plants of very distinct species.

"For many years the cities of New York and Philadelphia have been supplied with gas for lighting their streets and houses from coal of the Blackheath mines, and the annual quantity taken by Philadelphia alone has, of late years, amounted to 10,000 tons."

These Virginia mines were the first coal-mines opened for the market in the United States. Owned by an English company and competing only with English coals, they enjoyed for some time the exclusive coastwise trade of the Union. The cost was so great that few individuals used the Richmond coals in the large coast cities, but burned wood for many years after the mines were opened.

In their nature these coals are very dry and gaseous, containing a large amount of gas, but producing a limited amount of bitumen. The coke is poor, physically, but is pure. It makes a better gas than any of the Nova Scotia coals, and rather more per pound than the coals of the Eastern Alleghenies, but it does not compare with the rich gas coals of West Virginia, or the Pittsburgh and Youghiogheny fields.

For some reason this region has ceased to have the importance it once possessed, and has added practically nothing to the coal production of the United States for many years past. This may be due in a great measure to the many troubles and faults in the coal-seams, and also to the increased expense of mining in the deep shafts necessary to reach the coal. The methods of mining are also far behind the advanced systems of the middle and western fields. "The mining operations in the Richmond coal-fields," says S. H. Daddow, "have been generally of the most primitive character, and may be referred to the early days of the elder Stephenson, in England. Instead of improving and progressing, they have gone backward for the last ten years, and are now less able to mine coal with economy than they were twenty years ago. Most of the proprietors insist on the bucket being the best and cheapest mode of drainage, and keep on raising water instead of coal."

This was written many years ago. Since then the mines have been idle for a number of years, but at the present time some talk is heard of opening up the old Midlothian properties in Chesterfield. With the abundance of cheaper and better fuel coming to an already overstocked market, the times do not seem opportune for such action.

Five years after the Virginia mines began operation, we hear of the discovery of coal in Ohio by one Lewis Evans (1755), following which, in 1760, anthracite coal was first discovered in Rhode Island. Here, as in the Richmond field, Nature withheld her hand at a time when a more perfect formation would have given us a boundless bed of anthracite and another of bituminous coal at or near tide-water, and so have made unnecessary the long haul from our inland coal-fields to the seaboard,—an expensive mileage that prevents us from meeting England in the so-called "markets of the world." For while our coal sells for less *at the mines* than any European product, the expense of hauling to tide-water must be added, a burden to the American operator often twice as great as the cost of the coal, and to the English competitors, with their mines at the seaboard, practically nothing.

CHAPTER IV.

HISTORICAL.

The influences which produced the anthracites of Pennsylvania also produced those of New England, but, the process being more intense, the value of the coal for fuel was in a measure destroyed. The latter beds are thin and irregular, full of faults, saddles, and troubles, together with all the ills following these peculiar conditions.

Many attempts have been made to work these coals by operators of experience, but after repeated and expensive experiments, the effort to compete with the great Pennsylvania coal-beds has been found to be useless, and their works have been abandoned.

In Rhode Island the outcrops frequently yield plumbago, and occasionally nests of almost pure graphite are found in the coal-beds. That near the surface is collected and sold as black lead, under the name of "British lustre," and is used for polishing stoves. Of these coals, Professor Hitchcock said, in 1839,—

"Ere long the anthracite of Rhode Island, and even that of Worcester, will be considered by posterity, if not by the present generation, as a treasure of great value."

Commenting on the above, Daddow says:

"The difficulty of profitable mining in these New England coal-fields will be evident to practical men. Most of the coal lies below water-level, and can only be reached with long, deep slopes or shafts; and, as the beds are thin, a great distance must be opened out to produce even a small amount of coal. The cost of erecting machinery and establishing mines under such conditions is great, and the operation of them expensive, while at best the coal can only be obtained at double the cost of ordinary mining operations in other thicker and more regular beds. But in addition to all these serious drawbacks, when the mines are opened and the proprietors commencing to realize, a sudden stop is put to the production of coal by a down-throw, a fault, or a thinning of the seam, which may continue to an indefinite extent."

Continuing the subject in chronological order, the next discovery of coal in the United States was by Colonel Croghan, a British officer, in 1763, who noticed it "on the south side of the Wabash River, in a high bank, in which were several fine coal-veins."

In 1766 anthracite coal was discovered in the Wyoming Valley. In that year James Tilghman, of Philadelphia, sent a small sample of it to Thomas and William Penn, in London, with his compliments, and remarked, "This bed of coal, situated as it is on the side of the river, may some day or other be a thing of great value." To which Thomas Penn returns his compliments and thanks for the piece of coal, "which we will have examined by some person skilled in that article, and send their observations on it."

In 1768 mention of coal in the Wyoming Valley is made in a draft by Charles Stewart, showing a large tract of land on the west side of the Susquehanna, opposite Wilkes-Barre, which has "stone coal" marked on it. It is claimed that two brothers by the name of Gore, members of the Connecticut colony that settled in the Wyoming Valley, were the first to use anthracite coal in this country. They were blacksmiths, and used it in their forge fires in this same year.

In the following year (1769), Thomas Penn, in a letter of instructions to his nephew, Lieutenant-Governor John Penn, says:

"We desire you will order 5000 acres of land to be laid out about Pittsburgh, including the town, which may now be laid out, and I think, from its situation, will become considerable in time. . . . I would not engross all the coal hills, but rather lease the greater part to others, who may work them." Many a brother operator will justify the wisdom of the concluding sentence.

In 1770 coal was discovered in the middle district of the anthracite region of Pennsylvania near Mahanoy and Shamokin. It is marked on Scull's map of that date. Little mining was done here, however, until about 1834. Scull's map of Pennsylvania indicates "coal" about the headwaters of the Schuylkill. It is also marked as present in Berks County and in Pittsburgh.

During the Revolutionary War, in 1776, coal was taken to Carlisle for the United States army. It was taken to Harrisburg in boats or arks, and from there hauled in wagons to Carlisle. This was the first shipment of anthracite coal ever made in this country.

In the year following (1777), Captain Hutchins published in London a map on which coal is marked at various places along the Ohio River.

In 1783, Dr. Schopf speaks of coal in the Swatara Creek in Lebanon County, Pennsylvania.

In 1784 the Penns granted the privilege of mining coal in the "great seam" opposite the town of Pittsburgh "at the rate of £30 for each mining lot extending back to the centre of the hill."

In 1785, Samuel Boyd patented a tract of bituminous coal in Clearfield County, Pennsylvania.

Anthracite coal was first discovered in the Lehigh region in 1791 by a poor hunter named Philip Ginter, near the present town of Mauch Chunk. Reading Howell's map of Pennsylvania, published in 1793, indicates coal near Tamaqua. Seven years afterwards William Morris took a wagon-load of this coal to Philadelphia, a distance of nearly a hundred miles, but was unable to sell it.

In 1801, Benjamin Henfrey claimed to have discovered coal near Baltimore.

In the year 1803 two arks of Lehigh anthracite were successfully floated to Philadelphia through the Lehigh and Delaware Rivers. They contained 200 tons of coal. Five started, but three were wrecked. The coal could not be made to burn, and was thrown away as useless for any purpose except to "gravel foot-walks." The voyage of the arks is thus described:

"The descent of the river for the first fifteen miles from Mauch Chunk was exceedingly rapid, the fall being some 300 feet. It was a bright and cheerful morning, after the stream had attained the usual high-water mark, that the arks were cut loose, and, each equipped with six men, began at once the descent of the rapids. Now the torrent roars; the waves whirl and dash madly around the boats; the men at the oars, with faces wild with animation and excitement, and with muscles full distended, run to and fro upon their narrow platforms; the pilot, with energetic motion and speech, addresses the steersman; the steersman, with like gesticulation and vehemence of manner, responds to the pilot, and then all hands make desperate plunges at the oars! Now the boat, shaking and cracking, swings its cumbersome form around a submerged rock; now it sheers off in a counter current towards the shore, and then bending around, again dashes forward into the rolling waves, when—cr-a-sh! je-boom!—it rises securely upon a ledge of rocks half concealed beneath the surface of the water. A moment serves to complete the wreck, and then the men, seizing oars and planks, make good their escape to the shore, leaving the broken and dismembered ark to its fate, and the cargo to the curious speculation of the catfish and eels."

Of the arks used in transporting coal from the Wyoming Valley, it is stated that they were "rudely constructed craft, 90 feet long, 16 feet wide, and 4 feet deep, with a capacity of 60 tons. Each end terminated in an acute angle, with a stern-post surmounted by a huge oar, some thirty feet in length, requiring the strength of two stout men to ply it.

"Some 10,000 feet of lumber were used in the construction of the ark, and its total cost was $70.

It took four men seven days to navigate it to tide-water, the cost of the trip being about $50. Only two-thirds of the arks started down the river reached their destination, one-third generally going to pieces on the bars and rocks. The cost of transporting a ton of coal to tide-water by this method was about $5 per ton, but as it sold in Philadelphia at $10, it left a profit of $5 per ton." The ark was sold for the lumber it contained for about $15.

In 1804, William Boyd shipped the first ark-load of the Clearfield semi-bituminous coals down the Susquehanna River to Columbia, a distance of 260 miles. We are informed that it occasioned "much surprise." Other arks followed, and all towns along the Susquehanna River were soon familiar with the merits of Clearfield semi-bituminous coal. From this small beginning shipments have increased from this region to an output, yearly, of several millions of tons!

The Indian name for Clearfield was Chingalacamouche, and signified "The Clear Fields." It was so called because there was a large clear space there which had been made so by the buffaloes. These animals congregated there in immense numbers many years ago, tramping down and destroying all the small trees and underbrush in the neighborhood, thus making "The Clear

Fields" that the Indians found there, and from whom the pioneer settlers got the name. Of this,

"I know not what the truth may be;
I tell the tale as 'twas told to me."

In the same year the first discovery of coal was made west of the Mississippi by the exploring expedition under the leadership of Lewis and Clarke, who traced coal along the banks of the Missouri River and along the Yellowstone.

In this year anthracite coal was first successfully used in stoves in Philadelphia.

David Berlin claimed to have discovered and used coal in his blacksmith forge at Valley Forge, on the Schuylkill River, about seventeen miles above Philadelphia. This was in 1806, the same year that Captain Pike discovered coal on the Osage River, Kansas.

In 1812, Colonel George Shoemaker, of Pottsville, loaded nine wagons of coal and hauled it to Philadelphia; with difficulty he sold two loads and gave the other seven loads away. He was regarded as an impostor for attempting to sell stones to the public as coal, and had some difficulty in getting out of the city to avoid arrest.

One of the loads was bought by White & Hazard, operating wire-works at the Falls of Schuylkill. "A whole night was spent in the effort to make the coal burn, when the hands in despair quit their work, but left the door of the furnace shut. Fortunately, one of the workmen forgot his jacket, and returning found everything red-hot.''

And so the story goes: through trials and tribulations, discouragements and difficulties, Pennsylvania anthracite coal, the typical fuel of the world, made its worth known slowly but surely until it reached the superb proportions we witness to-day, —an annual production of over 50,000,000 net tons!

In 1815, William and Maurice Wirtz succeeded in sending one ark-load of coal to Philadelphia, through the Lackawaxen and Delaware Rivers.

In 1819 coal was first discovered in Centre County, in the neighborhood of Snow Shoe, by a hunting party, who observed the outcropping close by a spring. Daniel Weaver hauled a load of it to Bellefonte, Pennsylvania (distant about twenty-five miles), where it was tested at John Hall's blacksmith-shop and found to be of good quality.

Valentine & Thomas were the first to open operations at Snow Shoe, but the coal developments moved slowly until the building of the Lock Haven and Tyrone Railroad and its connecting line, the Bellefonte and Snow Shoe Railroad, in 1857–59. In 1859 not over 10 miners were employed in the Snow Shoe region. In 1903 there were employed

1200 miners, producing a yearly output of over 500,000 tons.

The coal from this region is well adapted for forge and blacksmith use, if properly mined. It is also particularly well suited to the manufacture of coke, of which many thousand tons have been made and tested under the most exacting work. In 1820 the first shipment of coal from Allegheny County, Maryland, consisting of a few thousand tons, was sent down the Potomac River in boats. In 1823 the first cargo of anthracite coal was shipped around Cape Cod by vessel, consigned to the Boston Iron-Works. Shortly afterwards (1825) anthracite coal was first used successfully for steaming under boilers at Phœnixville, Pennsylvania.

From Karthaus, in Clearfield County, came the first cargo of semi-bituminous coal ever shipped to Philadelphia from a Pennsylvania mine. This was in 1828. The coal was taken down the Susquehanna River to Port Deposit, at the head of the Chesapeake Bay, and thence by vessel to Philadelphia. About the same time a cargo was sent to Baltimore.

In 1832 the Blossburg coals first attracted attention. Two years later coal was discovered in Alabama by Dr. Alexander Jones, of Mobile.

Blast furnaces first used anthracite coal for smelting ore in 1837 at Mauch Chunk and Pottsville.

The first shipment of semi-bituminous coal from the now famous Cumberland region in Maryland was made by rail to Baltimore, over the Baltimore and Ohio Railroad, in 1842. The total tonnage for that year was 1708 tons. Now the same region produces several millions of tons annually.

The same story of wonderful development comes from the Broad Top region, where the coal first sought the market in 1856; and the youngest of them all, the famous Pocahontas region in Virginia, barely twenty years old and already showing a production of several millions of tons annually.

That it was not all plain sailing in bringing the development of American coals to its present position is a matter of history. The road to supremacy in the coal trade of the world—a position now finally reached—is strewn with the financial wrecks of companies and individuals, as are the trackless wastes of the deserts with the whitened bones of former ill-fated travellers.

Nor was the fate of these adventurous American miners different from that of those Englishmen who many years ago embarked in similar enterprises, as note the following from Grey's "Chorographia" (1649):

"One merchant imployeth five hundred or a thousand in his works of coale; yet for all of his labour, care and cost, can scarcely live by his trade; nay, many of them both consumed and spent great estates and dyed beggars. I can remember one, of many, that raysed his estate by coale trade; many I remember that hath wasted great estates. . . . Some South gentlemen have, upon great hope of benefit, come into this country to hazard their monies in coale-pits. Master Beaumont, a gentleman of great inginuity and rare parts, adventured into our mines with thirty thousand pounds: who brought with him many rare engines, not known then in these parts,—as, the art to boore with iron rodds, to try the deepnesse and thicknesse of the coale, rare engines to draw the water out of the pits, wagons with one horse to carry down coales from the pits to the river. . . .

"In a few years he consumed all his money, and rode home upon his light-horse."

CHAPTER V.

GEOGRAPHY.

Sixty years ago an English writer on coal, after giving a full and exhaustive treatise on the extent and richness of the transatlantic coal-fields, dismisses a general and meagre account of the American fields with a foot-note, as follows:

"The common fuel in the cities and towns of the United States consists chiefly of wood, of which there are various kinds. The best is the celebrated hickory-tree, which commonly fetches a price equivalent to about twelve shillings per load; it is a durable fuel and does not soon die out. Oak billets are next in esteem, and sell for nine shillings; gum-wood, dog-wood, and pine-wood are an inferior description of firing, and fetch six or seven shillings the load, according to circumstances.

"The quantity to be accounted a load is fixed by law, and the logs, which are about four feet long on the cart, are sawn into short billets, previous to being piled in the cellars of the consumer by the hawker of the fuel, or some person who accompanied him with a saw on his back. The poor mostly burn fagots or pine-wood."

How quaintly it sounds to the present-day coal dealer at retail, to read the above and then to reflect that it was written only sixty years ago! To-day, where one load of wood is sold to some wealthy customer for use in his luxurious open fireplace, at ten to twelve dollars per cord, fifty loads of the hard, bright anthracite coal are disposed of to all sorts and conditions of men; from the winter's supply of egg size to the prosperous householder, down to the shivering tenement lodger, who buys the pea size by the shovelful. For domestic use anthracite coal is almost universally employed in America, and the man "with a saw on his back" has passed into oblivion. Fifty millions of tons each year of anthracite coal alone are now considered necessary to keep "Brother Jonathan" warm in winter and, besides cooking his meals, to perform various other utilitarian purposes.

"It is only when we turn to North America," writes Mr. Jevons in 1866, "that we meet a country capable of comparing in coal resources with our own, *and the future of England greatly depends, therefore, upon the future of America.* The areas of American and British coal-fields have already been compared, and the current statement is sufficiently true, that the American fields exceed ours as 37 to 1.

"Canada, indeed, is devoid of any trace of the coal-measures and presents a remarkable contrast to the regions by which it is surrounded. Newfoundland, New Brunswick, and Nova Scotia contain the northeasterly extensions of the great American fields. But so far as yet known the coal-measures are here more interesting to the geologist than to the economist."

As compared with the transatlantic coal-fields, the American fields easily take first rank; in fact, the geography of American coals is to-day, practically, a description of the United States.

Twenty-eight of the States make regular returns of coal shipments, in their annual reports, from hundreds of operating collieries, interspersed at irregular distances over a vast territory, extending from the Atlantic Ocean on the east to the Pacific Ocean on the west, and from the great lakes on the north to the Gulf of Mexico in the south. This immense region embraces the States of Alabama, Arkansas, California, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Missouri, Montana, New Mexico, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wyoming, and Indian Territory.

Two other States, Rhode Island and Nebraska, have deposits of coal within their borders, but are not to-day producing any tonnage, and, therefore, are not counted among the coal-producing States. To establish geographical lines, circumscribing the coal-fields of this country, would, therefore, be to include the boundaries of all the aforementioned States, as new openings are constantly being made at different points in each. Regions before unknown in a dozen years spring into existence, increasing the actively producing territory by many hundreds of acres.

A general description of the American coal-fields must suitably begin with the anthracite region of Pennsylvania as being of the first importance.

Nearly all of the anthracite coal mined in the United States comes from Pennsylvania, but from a comparatively small part of it.

Geographically, the anthracite fields are situated about the middle of the eastern portion of the State and include the counties of Susquehanna, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Northumberland, and Dauphin, including an area of about 480 square miles. From this comparatively small section of our country, we have mined in the past eighty years—or say during a man's lifetime—over one and a half billion gross tons of anthracite coal! These eighty years may be said to contain the entire history of American coal. In that short time we have advanced in the world's coal production from the tail of the class to the head.

In 1749 the strip of Pennsylvania territory which includes all of the anthracite deposits and much more, a strip about one hundred and twenty-five miles long by thirty miles wide, was purchased by the proprietary government for the sum of £500, or, in our money, say $2500, about the cost of an American workingman's two-story brick house. From that investment we have realized nearly $4,000,000,000, the value of the coal mined, at tide-water!

Similarly, from the purchase of the bituminous coal-fields from the chiefs of the Six Nations, for a nominal sum, we have reaped a million-fold.

It is only fair to add that the value of the land was equally unknown to the seller and purchaser. It was not until a hundred years later that the anthracite trade, with an annual output of only 3,000,000 tons, could be said to have passed the line between a precarious experiment to a commercial success. At that time the anthracite coal business was scarcely twenty-five years old.

While the State of Pennsylvania produces almost the entire output of anthracite coal, there are small territories of this coal in Colorado and

New Mexico, and also in Virginia, but their combined output is small, not exceeding 75,000 tons annually. What are called the anthracite coal-fields of New England embrace a small territory in the eastern part of Rhode Island and Massachusetts. It is now generally admitted, however, that the coals coming from this territory are entirely graphitic and unfit for combustion.

It will therefore be seen that a description of the anthracite territory—in its geographical aspect—of Pennsylvania alone practically includes all of the anthracite coal-fields of the United States.

The anthracite coal-fields of Pennsylvania are divided into five principal divisions, as follows:

First.—The Southern, or Pottsville field, extending from the Lehigh River at Mauch Chunk southward to within a few miles of the Susquehanna River north of Harrisburg, the capital of the State.

Second.—The Western, or Mahanoy and Shamokin field, lying between the eastern head-waters of the Little Schuylkill River and the Susquehanna.

Third.—The Eastern, or Upper Lehigh field, lying between the Lehigh River and Catawissa Creek, principally in Luzerne County.

Fourth.—The Northern, or Wyoming and Lackawanna field, which lies in the two valleys from which its geographical name is derived.

Fifth.—The Loyalsock and Mehoopany field, named from the two creeks whose head-waters drain it. It lies northwest of the Northern field.

For trade purposes these five geographical divisions are grouped into three, as follows:

The Wyoming Region, embracing the entire Northern and Loyalsock fields.

The Lehigh Region, embracing all of the Eastern field and part of the Southern field.

The Schuylkill Region, embracing the Western field and part of the Southern field.

From this small territory is mined all of the anthracite or hard coal with which we are so familiar in our domestic economy,—the black diamonds of commerce upon which so much of our comfort depends.

Of the three regions above named, the Wyoming is by far the most important, producing as it does over 50 per cent. of the entire output of coal. The next in size is the Schuylkill region, with 35 per cent. of the production, while the Lehigh region comes last, with the remaining 15 per cent. of the total shipments.

In Colorado the only anthracite coal mined comes from the Grand River field, a territory whose geographical lines lie in the extreme western part of the State and extend across the line into the recently admitted State of Utah. The counties in which this field lies are Rio Blanco, Garfield, Mesa, Delta, Pitkin, and Gunnison.

Future developments may show increased territory of the anthracite field in Colorado, which at present is small.

In New Mexico the anthracite territory occurs in Santa Fé County. The coal is described as hard, dense, and of a brilliant lustre, containing 87 per cent. of fixed carbon and 5 per cent. of ash. The same authority states that in some places both anthracite and bituminous coal occur in the same mines, the heat of the porphyritic dikes which traverse the country undoubtedly having caused the transformation from one species into another.

As before stated, the anthracite territory in New England is conceded by the present generation to contain only hard graphitic coals unfit for combustion. This fact, however, does not deter the speculative ingenuity of its people from attempting to utilize the treasure so close to their doors. The latest attempt in this direction is the proposed mixture of the pulverized Portsmouth coal with enough pitch or crude oil to make it free burning, and then by machinery to form it into briquettes of suitable size for domestic use, in competition with the prepared sizes of Pennsylvania anthracite.

The idea is not new—I have given a similar instance, as practised in China, in a preceding chapter. On the Continent the manufacture of briquettes is quite an industry. It has also been tried in England with success.

In France the process is very simple. The coal is first carefully dried and then automatically mixed with a very small quantity of pitch. The machine, by pressure, forms the pasty mixture into briquettes from the size of an ordinary brick down to a ball the size of an egg. The only objection to their use abroad is owing to the resultant smoke, but as New England is now well used to that, in the consumption of bituminous coals, the objection would have little weight. The advantage would be the development of a territory long idle and the production of a fuel convenient in size, uniform in quality, of great heating power, and free from the *bête noire* of all coal users,—clinkers.

In Ireland, the drying and solidification of *peat* into hard blocks of fuel, which can be practically used in furnaces as well as in domestic fireplaces, have been successfully accomplished by the Blunden process, to work which a limited liability company, called the Peat Products Company, has been formed. Mr. Blunden is an English engineer, and has devoted himself for several years to the perfection of this process of drying peat. In it all pressure, heat, and foreign admixtures are dispensed with, yet the moisture of the peat is evaporated down to 8 per cent. It seems that in order to dry peat thoroughly and quickly, air must be brought into contact with a glutinous substance in the peat called pictine; this pictine, on combining with the acetic acid in the peat, begins at once to contract; the contraction goes on with irresistible force inward, so that the water is driven to the surface, and is evaporated into the atmosphere. When dry, the previously moist, friable peat is found to have contracted into a compact, hard substance, which can be polished like ebony. The machine in which the pictine of the peat is liberated and the process of consolidation commenced is that invented by Mr. Blunden. These machines can be worked by hand, but are generally worked by an engine of four or more horse-power. They can be set up on the bog, and, as fuel is supplied on the spot, they require no more expense in working than the wages of a few operatives. The blocks are delivered from the machines in cylindrical rolls, nine inches long and four inches in diameter, with a hole in the middle. These rolls are then placed on wires in a windy spot, and are dry and ready to burn in from ten to twenty days.

The cost of manufacture is said to be about 3*s.* 6*d.* a ton. A hand machine can deliver one ton of hard fuel per diem, and a twin machine, worked by a four horse-power engine, can turn out from six to eight tons of good fuel per day. A superior kind of charcoal is made from this peat fuel, together with the by-products of gas, tar, peat, oil, etc.

A small factory was erected in Kellswater, County Antrim, on the property of Lord O'Niell, in March, 1894. The work was so successful that a larger factory was erected the following year, so as to turn out from 2000 to 3000 tons a year.

Other factories have been successfully established on the moor at Rannoch, in Perthshire; on the Crinan Canal, West Ayrshire; and in the Tongean Valley of the Somme, in France.

CHAPTER VI.

AREA.

It will doubtless surprise the general reader, particularly one dwelling in the Middle and Eastern States, to be told that, large as the product of anthracite, or hard coal, is in Pennsylvania and the United States, the output of bituminous, or soft coal, is more than four times as large, and the territory in which the soft coal is found more than a hundred times as extensive as the anthracite fields.

The latter—in the East especially—is usually the fuel used for domestic purposes, and in general conversation when the word "coal" is used we think only of the hard, bright anthracite glowing in the grate or stove of our dwellings, while the duller and less sparkling brother,—bituminous,—if we think of it at all, we connect with the humble uses of the village smithy. This ignorance of soft coal and its relative importance in the trade is not confined to the general reader: many retail dealers, judging of the value of the two coals by the standard of the number of tons sold from their yards of each kind, conclude that the sale of bituminous coal, estimated by their experience, must be very limited. The coal operator—that much criticised and abused individual—knows better. He scans the reported tonnages each year, and finds that, great as the development of anthracite had been, it is far behind its rival—the less brilliant but more powerful bituminous—in the United States, while in the world's production of coal it is but a fractional part of the whole. The operator is aware of the fact that all of the great ocean steamers, with a few individual exceptions, are propelled between the two hemispheres by the energy generated from bituminous coal, that the great navies of the world use nothing else, and that the large majority of locomotives are urged forward along the rails by the same kind of fuel. These, together with the long list of rolling-mills, factories, and industrial works of all kinds using bituminous coal, consume vast quantities, in comparison with which the amount used in blacksmiths' forges is insignificant and unimportant.

The great bituminous fields of the United States are divided as follows:

First.—The Triassic region, comprising what is known as the Richmond basin, in Chesterfield and Henrico Counties, Virginia, and the Deep River and Dan River fields in North Carolina. The coal formations here are of a more recent period than Appalachian or Western coals, which are of the Carboniferous age. Daddow and Bannon describe this region as follows:

"These are small, impure, irregular, and insignificant deposits compared with the great fields of the West, but being located in prosperous districts, remote from the regions of the true bituminous coals, they become of great local value.

"There are five distinct coal formations in Virginia and the Carolinas. Three of these appear to be creations of relatively different ages, but all of later periods than those of the true formations.

"The Richmond coal-field, near Richmond, in Virginia, lies within the granite basins of the primitive formations, but is nevertheless the latest creation. The Piedmont coal-field is farther inland, in the counties of Prince Edward and Cumberland, and is within the gneissic basins, or the crystalline, sedimentary deposits of the metaphoric era; but the coal is of an earlier period than that of Richmond. This field is, perhaps, part of a parallel formation with the Dan River coal-field. The Deep River coal-field, in North Carolina, is undoubtedly of a contemporary date with the Richmond and Dan River coal-fields, but the composition of its lithological structure is materially different, owing to the character of the sources from which it was derived.

"The New River coal-field, in Montgomery County, Virginia, essentially differs from all other coal formations in this country, and is perhaps the oldest coal in existence, or the first creations of the Carboniferous age.

"Therefore we place the New River coal-field in an older position than the others."

Second.—The Appalachian region, the most important of the seven grand bituminous divisions, according to Mr. Parker,—from whose report is taken the following descriptions,—extends from the northern part of Pennsylvania in a southwesterly direction, following the Appalachian Mountain system, which it embraces, to the central part of Alabama. Its length is a little over 900 miles, and it ranges in width from 30 to 180 miles. Its area is about 62,690 square miles, covering nearly all of Western Pennsylvania, the southeastern part of Ohio, the western part of Maryland, the southwestern corner of Virginia, nearly all of West Virginia, the eastern part of Kentucky, a portion of Eastern Tennessee, the northwestern corner of Georgia, and nearly all of Northern Alabama.

All the coals are bituminous except for a little anthracite in Southwestern Virginia, and are of good variety in chemical composition and physical structure. They include the famous Connellsville coking coal, the Clearfield and Pittsburgh steam coals, the smithing coals of Blossburg and Cumberland, the gas coals of the upper Potomac and Monongahela Rivers, the Massillon and Hocking coals, the steam, gas, and coking coals of the Flat Top, New River, and Kanawha River regions, the Jellico coal of Kentucky and Tennessee, and the excellent coking coals of Southeastern Tennessee and Alabama.

Third.—The Northern field. This is altogether in Michigan, covering an area of 6700 square miles, and including nearly all the central part of the State, the central point being near the town of St. Louis, in Gratiot County, and the southern boundary passing a few miles south of Jackson, in Jackson County. The greatest thickness of the measures is found along a line extending from Ionia County to Saginaw, the thickest coal-beds lying along Six Mile Creek. The principal operations are carried on near the city of Jackson, in Jackson County.

The Michigan coals are of inferior quality when compared to those shipped by lake and rail into the State, and the imported coals are sold so cheap that there is little encouragement for the development of the Michigan field. The basins in which the coal deposits were laid down were unprotected by later deposits prior to the period of glacial movement, and were exposed to the action of that time. The exposure to the forces of nature before the time of the glaciers seriously affected the qualities of the coal formation, and much of it was worn away and destroyed by moving glaciers, what was left being buried under the *débris* of the glacial drift. These conditions have left the rock formations of Michigan with but few exposures, and actual boring is necessary to determine whatever of mineral value lies below the surface. Under these conditions this field has not been developed as rapidly as have the more favored localities.

Fourth.—The Central field. This important territory—the second in producing capacity—includes all of Indiana and Illinois and the western part of Kentucky. It has an area of 47,850 square miles, three-fourths of which is included in the State of Illinois. It is from this field, particularly the Indiana and Illinois portions, that the well-known "Block" coal—so called from its peculiar fracture into cubical blocks—is obtained.

In Illinois a line drawn from Hampton, in Rock Island County, to the junction of the Kankakee and Iroquois Rivers, would define approximately the northern line of the coal-field, but from the junction of these streams the boundary line deflects south to the vicinity of Chatsworth, in Livingston County, and thence eastwardly to the Indiana line. All the area south of the line above designated, except a narrow belt along the Mississippi to the mouth of the Ohio, and up the latter stream to Battery Rock, is underlaid by the coal-measures, and mostly all the counties within the above described boundary have some coal.

In Indiana the northern limit of the field is in Warren County, where it crosses the State line from Illinois. Its border line passes from Warren through the eastern part of Fountain County, the northeastern corner of Parke County, partly in Putnam and Owen Counties. It takes in something more than half of Greene County, part of Monroe and Martin Counties, the eastern part of Dubois, Crawford, and the western part of Perry County, crossing the Ohio River into Kentucky near Cannelton.

In Kentucky the Central coal-field is in the western part of the State, and it is penetrated throughout its entire length by the Green River, which is navigable at all seasons, and which exposes in its course outcrops of all the twelve seams in the field. This State also contains in its eastern portion part of the Appalachian field.

Fifth.—The Western field, embracing all the coal areas west of the Mississippi, south of the forty-third parallel and east of the Rocky Mountains, including the States of Iowa, Missouri, Nebraska, Kansas, Arkansas, and Texas, and the Indian Territory.

In Iowa the northern limit occurs in Humboldt County. From here its eastern border runs in an irregular line to the southeastern corner of the State. The western border has not been well defined on account of the deep deposits of glacial drift material, but it is approximately along a sinuous line to Council Bluffs, on the Missouri River, which, with the entire southern boundary line of the State, completes the limits of the field in Iowa.

In Missouri a line drawn from the junction of the Des Moines River with the Mississippi, in the northeast corner of the State, diagonally across to the southwest corner, will have northwest of it nearly all the coal territory of Missouri. An arm of this territory, however, follows the course of the Missouri River eastward for a short distance in the central part of the State, and some coal is found near St. Louis. The total area is about 25,000 square miles. The separation of the Western coal-field from the Central field is made by the Mississippi River and its immediate valley.

In Nebraska the coal-field is in the southwestern corner of the State, but being on the edge of the field, the veins are thin, and so far have not been profitably worked.

In Kansas the coal territory occupies the eastern part of the State, occupying approximately one-fourth the area of the State.

In Arkansas the coal-measures containing workable beds are all within the area drained by the Arkansas River.

In Texas the coal-fields are in the north central part, occupying an area of 5000 or 6000 square miles, showing nine distinct seams of coal, only two of which, however, can be profitably worked. There is also some territory in the southwestern part.

In the Indian Territory the area containing available coal-measures is mostly exposed on the north side of the Ouachita Mountains, and in the prairie region of the northwest portion of the territory adjacent to Kansas.

Sixth.—The Rocky Mountain field, including the coal areas contained in the States of Colorado, Idaho, Montana, New Mexico, North Dakota, Utah, and Wyoming.

In Colorado the coal areas are divided into six independent fields, known as the Raton, South Platte, North Park, Grand River, Zampa, and La Plata. The first three lie east of the great Continental divide, and the last three west of it.

Together they cover an area of 18,100 square miles. In the other States included in the Rocky Mountain field no reliable estimates of the coal areas have yet been made.

Seventh.—The Pacific Coast field embraces the three States bordering on the Pacific Ocean,—California, Oregon, and Washington. The areas underlaid by coal-beds in this field have not been definitely determined. Of the three States named, Washington comes first in the quantity of coal produced, Oregon next, and California last. Washington contains a number of valuable beds of coal, possessing excellent coking qualities. Oregon also contains some good coals, but those found in California are of the lignite variety and of poor quality.

These conclude the seven great bituminous coal-fields of the United States, from which we are drawing about 250,000,000 net tons every year, in fearless confidence that our supply of bituminous coal is practically inexhaustible. That our English cousins are not so sure of their ability to continue their enormous production from their comparatively limited territory was long ago suspected, as evidenced by a letter from Professor Tyndall to Mr. Jevons:

"I see no prospect of any substitute being found for coal as a source of motive power. We have, it is true, our winds and streams and tides, and we have the beams of the sun. But these are common to all the world. We cannot make head against a nation which, in addition to those sources of power, possesses the power of coal. We may enjoy a multiple of their physical and intellectual energy, and still be unable to hold our own against a people which possesses abundance of coal, and we should have, in my opinion, no chance whatever in a race with a nation which, in addition to abundant coal, has energy and intelligence approximately equal to our own. The history of this nation is not in the hands of its statesmen, but in those of its coal owners, and while the orators of St. Stephen's are unconscious of the fact, the very life-blood of their country is flowing away."

As America is the only country possessing abundance of coal—as compared with England—and as our "energy and intelligence approximately equal" theirs, it is reasonable to presume that Professor Tyndall had us in his mind's eye when he wrote the above, some years ago. Nor were his surmises far from the truth. Yesterday we were but a few million tons short of England's enormous coal production; to-day we stand first in the coal-producing countries of the world.

CHAPTER VII.

CLASSIFICATION.

To classify the family of the carbons is no easy task. The simple definition of the word "coal" admits of many different constructions. In England some years ago a company leased "all the coal" contained in a certain tract of land and proceeded to mine it. In course of time the company mined a large quantity of some gaseous substance which the land-owners declared was not coal, and refused the lessees permission to mine it under the lease. When the case came up for adjudication the parties in interest produced a host of witnesses and expert miners and geologists, all ready to swear that the substance in dispute was coal, or was not coal, according to their individual views most in accordance with those of the plaintiff or the defendant. As a result of this mass of conflicting testimony the much-bewildered judge gave as his opinion that "to find a scientific definition of coal, after what has been brought to light within the past few days, is impossible."

More recently in this country an extensive lawsuit regarding freight rates charged on anthracite and bituminous coals evolved the curious contention that there was no distinction between the two coals, and that equal rates must apply, as the coals were practically one and the same commodity.

For the purpose of illustration, however, we may begin the classification of the carbon family by: *First,* the oldest and hardest of them all, the diamond, which is essentially pure carbon. *Second* comes the graphite or plumbago, a good example of which is the so-called anthracite coal of Rhode Island. *Third* is our famous Pennsylvania anthracite, of the hard, dry variety, with over 90 per cent. of carbon. *Fourth,* the iridescent, or peacock coal. *Fifth,* the schistose, or slate coal. *Sixth,* the pure lignite, or jet. *Seventh,* the imperfect lignite, or fossil wood. *Eighth,* the youngest member of the family, turf or peat.

These successive examples illustrate the gradual transition from vegetable to mineral substances. On examining pieces of anthracite coal some fragments are sure to be met with in which may be seen bits of charcoal, with the vegetable fibre as distinct as in freshly charred wood. These, in connection with its chemical composition, suggest that it was once woody matter. Additional evidence of this is afforded by the vegetable reticulated structure, which is detected by powerful microscopes, pervading the different kinds of coal; and even the ashes of anthracite still retain distinct traces of the vegetable tissue. Even the various genera of the plants which furnished the carbon are ascertained with precision. For examination under the microscope the coals are cut into thin plates, polished, and made transparent by the application of oil. Thus prepared, some display the compressed cellular tissue peculiar to peat; others the wood of coniferæ (the pine); others the palm, birch, etc. Some beds, again, appear but a mass of delicate leaves matted together when thus examined.

The coals of America are divided into two kinds, —viz., anthracite and bituminous. These are again subdivided into many varieties, of which mention will be made.

Of the two kinds of mineral coal anthracite is the most condensed and the richest in carbon. Its color varies from jet and glistening black to dark lead gray. It is clean, ignites with difficulty, burns with a short flame, without smoke, and has very little illuminating power. It gives an intense concentrated heat. Some varieties, when undisturbed while burning, partially retain their shape till nearly consumed, and some become extinct before they have parted with the whole of their carbon.

The constituents of anthracite coal are carbon, water, and earthy matter, in accidental and varying mixtures. There are also other ingredients present, besides the oxide of iron, silica, and alumina, which compose the earthy matter or ash; these are sulphur, bitumen, etc. All fuels, including in their designation naphtha, petroleum, asphaltum, are but representations of the successive stages in the change from vegetable to mineral matters. Anthracite is the condensed coke of bituminous coal. In some varieties the volatile bitumen is only partially expelled. These are known as "free-burning anthracite," "semi-bituminous," and by other commercial names.

The percentage of carbon in Pennsylvania anthracite ranges from 85 per cent. to 92 per cent. In the anthracite of South Wales the carbon has been found to reach as high as 95 per cent., and in a Russian variety 94 per cent.

The volatile matter may be bitumen, sulphur, and water, but only the last appears to be a necessary constant element. Water has been found in the largest quantity in those coals which are most thoroughly freed from bitumen, as the Rhode Island anthracite. According to the analysis of Dr. C. T. Jackson this often contains from 9 to 13 per cent. of water.

The ashes are the earthy matters, including in part those which constituted a portion of the original woody fibre, and such as may have been subsequently introduced during the changes this has undergone. The manner in which the original potash has been removed from the vegetable substances is not understood.

According to the color of these ashes the coals are classed as "Red Ash" and "White Ash."

The red ash contain a considerable proportion of oxide of iron, which gives them a reddish color. They are generally more easily kindled and a more free-burning coal than the white ash, but from the liability to clinker or form cinders, which melt and adhere to the walls of the grate or furnace, they are not so much esteemed for purposes which require considerable draft as the white ash variety, which shed their ashes freely. To burn in open grates, with a moderate draft, the red ash coal is preferred by many. For making pig-iron in blast furnaces the preference seems generally to be for white ash anthracite. This may be owing to the slight difference in the percentage of carbon, the less proportion in the red ash being made up by the greater amount of ashes.

The fact that the physical structure of the white ash is harder, better, and more suited to carry the burden in a blast furnace may also have something to do with the preference usually given to it.

A comparison of twenty-three analyses of different white ash Pennsylvania anthracites gives an average of 4.62 per cent. of ashes. Another comparison of twenty-one varieties of red ash Pennsylvania anthracite gives an average of 7.29 per cent. of ashes. The latter, therefore, contains 2.67 per cent. more of ashes than the white ash coals. Of this 2.67 per cent., about one-tenth, or five pounds to the ton of coal, is iron, which goes to increase the product of the furnace.

Sulphur, which renders any fuel in which it is appreciably present objectionable for use in the manufacture of iron, does not appear to be found in either variety of anthracite any more than in the others. Professor Rogers gives the following essentials for a good anthracite fuel for steaming or domestic use:

1. "Great actual heating power.

2. "Ease in kindling and rapidity in burning.

3. "Little earthy matter, and this as infusible as possible.

4. "Little or no sulphur.

5. "Volatile matters should be free inflammable gases, not bituminous, causing smoke; and only enough of these to expedite combustion, as the more fixed carbon the greater the heating power.

6. "Neither a tendency to crumble in the fire, nor to obstinately retain their form while burning.

7. "The lower the temperature at which an anthracite will kindle and maintain itself burning,

the more manageable, more active, and more economical will it prove.

8. "The better the coal unites the tenacity necessary for economical transportation with the medium amount of frangibility in the fire, the larger the effective results of a given quantity, from the time it leaves the mines.

9. "The greater the aggregate of positive heating power, rapidity of combustion, and compactness of storage, comparably assembled in a coal, the nearer does it approach the ideal standard of a perfect fuel."

The relative value of fuels is determined by the quantities of water evaporated by a certain weight of each coal. In the earlier experiments made in this country and in England the results obtained appeared to establish a law,—viz., that the richer a coal is in fixed carbon, the greater is its heating power; and the anthracites were thus classed as of higher value, weight for weight, than the bituminous coals.

It was the opinion of English engineers that "the strongest fuel contained the least gas," and, *vice versa*, that "bituminous coal had no greater heating power than the coke after its gases were expelled." It was shown by laboratory experiments that one pound of Pennsylvania anthracite coal evaporated 15.56 pounds of water, while a pound of Scotch bituminous evaporated only 7.74 pounds of water, and of the best English bituminous only 9.07 pounds of water.

These results, it is well known, are not sustained in actual practice.

The German chemist Wetter states the simple law, that "the heat is proportional to the quantity of oxygen which enters into the combination, whatever may be the nature of the combustible."

Berthier, the French chemist, recognizes this law. It is also admitted by Dr. Muspratt, and the various and voluminous determinations by W. R. Johnson are generally in accord with it.

As hydrogen and the gaseous products of its combination with carbon consume much larger proportions of oxygen than the same weight of solid carbon, the presence of these increases the heating power of the fuel. But the changes of structure and of physical properties, which their increased proportion induces, soon imposes a limit upon the advantage they confer, *and each variety of mineral coal is found to be adapted for some particular uses in preference to the others.*

Only a general idea can be given of the locality in which the red ash and white ash coals occur, as they frequently overlap in the several fields of Pennsylvania anthracites, but roughly the Lehigh coals come first in hardness and density, and have a white ash. These include the Green Mountain, Black Creek, Hazleton, Beaver Meadow, and Panther Creek.

These coals have always been, and are now, the standard of excellence among the many varieties of anthracites, and are so recognized in the trade. Many a ton of inferior coal has found its devious way to the consumer under the password "Lehigh" which never came from the region, but, to paraphrase a familiar proverb, "It's a wise piece of coal that knoweth its own origin." These coals are generally of the "white ash" variety.

The next are the Wyoming coals, including Carbondale, Scranton, Pittston, Wilkes-Barre, Plymouth, and Kingston, many of which are white ash, while some are semi-anthracite.

A recent writer gives the following interesting account of the first struggles of "Wyoming" coal for recognition:

"Coal was first discovered in the Wyoming Valley in 1805, at Plymouth, Pennsylvania, by John and Abijah Smith, two brothers, who had come from Derby, Connecticut, in 1805. In 1807 they shipped their first boat-load of coal to Columbia, Pennsylvania. Anthracite coal at that time was not fully understood as to burning in an open grate, but was used in blast furnaces, where artificial blast was employed to produce combustion.

The Smith brothers accompanied this load of coal, and also took along a stone-mason with all necessary tools to set up grates in houses, in order to demonstrate its excellent properties for heating purposes. Several houses in Columbia were supplied with grates, in which glowing fires of "stone coal," as it was then called, were made, and careful instructions were given in regard to maintaining the fires. Notwithstanding the thorough arrangements and preparations made for the introduction of coal for domestic purposes, it was only after a struggle of several years that they were able to gain a profit on their enterprise."

Mr. Pierce is authority for the statement that "up to 1820 the total amount of coal sent from Wyoming is reckoned at eighty-five hundred (8500) tons," and the same authority says that Colonel Washington Lee in 1820 "mined and sent to Baltimore one thousand (1000) tons, which he sold at eight dollars per ton."

The North Branch Canal was completed to the Nanticoke dam in 1830, and opened in 1831. The first boat, the "Wyoming," was built by the Hon. John Coons. It was launched and towed to Nanticoke, where it was loaded with ten tons of coal, a quantity of flour, and other merchandise destined for Philadelphia. The "Wyoming" passed down the river to Northumberland, where it entered the

Pennsylvania Canal, and proceeded, by way of the Union and Schuylkill Canals, to Philadelphia. On her return trip she brought back a cargo weighing fifteen tons, was frozen in the ice at New Buffalo in January, 1831, and arrived at Wilkes-Barre three months after the date of her departure. Thus it is proved that the shipment of coal from this region was commenced earlier than is reported in statements of the coal production of the different regions.

In 1843 the completion of the Lehigh and Susquehanna Railroad from Wilkes-Barre to Whitehaven opened up a new avenue for taking the Wyoming Valley coal to market. From this time on the history of the coal trade of this region is well known, and its greatly increased production may be seen by a glance at the tables published for each year.

The coal deposit of the Wyoming Valley lies in one large basin, about 54 miles long and an average of about 3½ miles in width,—a deep subsidence, shaped like a huge boat, lying between the Wilkes-Barre Mountains on the south side, and the Kingston and Capouse Mountains on the north side. The aggregate thickness, at the deepest point, is about 90 feet, divided into ten separate seams. The greatest depth is in Hanover Township, midway between Wilkes-Barre and Nanticoke, where the "red ash" (the lowest seam) is 2200 feet below the surface.

The "red ash" coals are generally found in the Schuylkill region, and include Lorberry, Lykens Valley, East Mahanoy, and Shamokin.

The efforts made by Colonel Shoemaker and others in 1812 to introduce this coal into Philadelphia, which nearly resulted in his arrest and imprisonment as a common impostor and swindler, have already been related. It remains only to add that the men who obtained a writ from the Quaker City authorities denouncing the colonel as "a knave and a scoundrel," for trying to impose *rocks* on them for coal, were the very men to whom he had given the coal for nothing!

CHAPTER VIII.

BITUMINOUS AREA.

American coals are generally described as of two kinds, anthracite and bituminous, but these general terms include a great variety of coals. The anthracites have been described in a preceding chapter. It is now proposed to attempt a classification of the coals known as of the bituminous variety, which differ both in chemical analysis and in physical structure.

Under the heading Bituminous are included the famous steam coals from the Pittsburgh and Clearfield regions, mentioned in a previous chapter as part of the Appalachian field; the smithing coals from Blossburg and the Cumberland regions; the gas coals from the upper Potomac and Monongahela mines; the Massillon and Hocking coals; the coking coal of the Connellsville region; the Flat Top, New River, and Kanawha River regions; the Jellico coal of Kentucky and Tennessee, and the coking coals of Alabama.

The "Block" coal of Indiana and Illinois is also of the bituminous variety, differing from the others, owing to its peculiar fracture into cubical blocks, and the brown "lignites" of the Western slope and the South are also included in the list, which in their composition and structure embrace a wide range of analysis.

The bituminous coals of Pennsylvania rank first in importance, Western Pennsylvania being one unbroken bituminous coal-field of superior coals, ranging in solid carbons from 59 to 64 per cent.; in volatile matter from 30 to 34 per cent.; from 3 to 6 per cent. ash; about 1 per cent. water, and 1 per cent. sulphur.

Its value was known to the French before Fort Duquesne became the English Pittsburgh, and its abundance has made this city the principal centre of the iron manufacture of the United States. From this point fleets of boats loaded with Monongahela Valley coal pass down the Ohio River to Southern and Southwestern cities with each rise in the rivers.

The bituminous deposits in Pennsylvania form the northern extremity of the great Appalachian coal-fields, and contain almost every variety of coal. "The greater part of the coal mined in this field is true bituminous coal, containing 20 per cent. and upward of volatile combustible matter, but in the detached deposits of Tioga, Bradford, and Huntingdon Counties, and along the summit of the Allegheny Mountains, the coal has a semi-bituminous character, containing only from 15 to

18 per cent. of volatile matter. The bituminous coals of Pennsylvania are known the country over for their admirable qualities. Coal for domestic use, steam-coal, gas-coal, coking-coal, blacksmithing-coal, all are found in wonderful variety and profusion in the Pennsylvania measures and of unsurpassed quality for each purpose. To the cities of the Atlantic coast, to those of the extreme South, and to those of the far West, Pennsylvania coal goes constantly, and is in steady demand."

From Westmoreland County comes the famous gas-coal, unsurpassed by any in the world for its excellent gas-producing qualities. This county alone produces about 6,000,000 tons of gas-coal annually, which finds its way to market over the Pennsylvania Railroad, the Baltimore and Ohio Railroad, and their connections. Recently large quantities of this coal have been exported to Cuba.

The "Clearfield Coal," so called from the county bearing the same name, is classed as semi-bituminous, having less than 20 per cent. of volatile matter (flame). What is lost in this component part, however, is gained in carbon (heat), and these coals are in great demand for steam and rolling-mill fuels; they are also distinctly advantageous for locomotive and steamship uses. Their nearer proximity to the Atlantic seaboard is also of advantage to the consumer, as the transportation from the mines is less.

To the south of these fields, in Maryland, is the "Cumberland" region, with coals similar in character to the "Clearfield" coals, and seeking the same market.

From the "Broad Top" district comes an excellent semi-bituminous coal, one of the first to establish its claims as a steam-raiser among the Allegheny coals of Pennsylvania. The first coal ever used in this district was dug out of the bed of Six-Mile Run, near the Mountain House, by a blacksmith named Nathan Horton, who settled there about 1760. Mr. William Foster, of Hopewell, a life-long resident of Broad Top, says Mr. Horton told him that he dug the coal himself from the bed of the run and used it in his blacksmith shop, about a mile distant. In 1856 the coal was again opened at the junction of Six-Mile Run and Shreeve's Run. Ben Foster and Dave Shackler dug the coal, "sledded" it to Riddlesburg, built an "ark," and ran it down the Susquehanna River, probably below Harrisburg. The first profitable mine in "Broad Top" was on Shoup's Run, near where Dudley now is. The "Cook" mine was opened by John Cook, who lived at what is now Broad Top City. He sold coal to pedlers, who took it as far as Hagerstown, Maryland.

The "Reynoldsville" district is centred in Jefferson County, joining Clearfield County on the west. Here the semi-bituminous veins are probably at their best, and from numerous collieries an enormous and steadily increasing tonnage of high-grade coals is transported to the markets of the North and Northwest over the Buffalo, Rochester and Pittsburgh Railway, and by the Beech Creek and Reading Railroad systems to tide-water.

In Jefferson County occurs also the famous "Punxsutawney" field, from which comes a remarkably pure coal, rich in volatile matter, and closely approximating the gas-coals of the more western fields. The physical structure of this coal —the "body," as it is called—enables the consumer to put it in use under a forced draft which would carry lighter and free-burning coals out of the stack or chimney unconsumed. The high volatile percentage, causing a long flame, makes it a particular favorite among the brick-makers.

The coal from the "Punxsutawney" field is shipped over the Pennsylvania and Northwestern Railroad, connecting with the Pennsylvania Railroad at Bellwood.

The Allegheny coals include the mines along the main line of the Pennsylvania Railroad in the neighborhood of Sonman, Gallitzin, South Fork, Portage, Ben's Creek, etc. In this district occurs the "Miller" seam, coal which burns, without forming any clinker, to a fine white ash. The coal is remarkably pure, and, owing to the absence of clinker, is a prime favorite in manufactories throughout New England, where for the most part no blast is used, and where combustion is procured by natural draft alone.

From the North Pennsylvania district come the "Blossburg" and "Barclay" coals, both fine steam-raisers. This is one of the older bituminous districts, coal having been mined and shipped from here during the past fifty years. The annual output from this district approximates a million tons annually.

South of these in Centre County is the "Snow Shoe" district, embracing a compact body of semi-bituminous coal about eight miles square, of which mention has been made in a previous chapter. The entire district is owned and operated by the Lehigh Valley Coal Company, and the natural outlet for the coal is along the line of the Lehigh Valley Railroad.

In the Cambria-Clearfield district we have the same kind of coal as that coming from the Clearfield region generally. The new Black Lick field, but recently developed, promises a large tonnage of semi-bituminous coal.

Somerset County gives us the Meyersdale district, from which a good deal of coal is sent to the Atlantic seaboard and sold in the market as "Cumberland," as it is said to be mined from the same seam of coal as that being worked in Maryland.

In Mercer County we have an excellent bituminous coal, which, together with that coming from Butler County, is sold very largely in Buffalo and across the line to our neighbors in Canada. The coal is of good quality, easily mined, and bears transportation well.

The "Dagus" district is in Elk County, and has an annual bituminous coal tonnage of over 700,000 tons annually. This coal finds its way to market over the Erie Railroad. It is a strong steaming coal and contains many desirable qualities in its physical construction. From the foregoing various bituminous coal districts in the State of Pennsylvania there is mined and shipped an aggregate total of nearly 100,000,000 net tons, which, added to the anthracite production of about 50,000,000 tons, will foot up close to 150,000,000 tons of coals produced in Pennsylvania alone each year, and making that State by far the greatest coal-producing State in our Union.

The next in importance is the State of Illinois, with an annual bituminous coal production of about 33,000,000 tons. While Illinois ranks second in coal production, it is first in coal area. It is about four times as large as the bituminous area in Pennsylvania, more than twice as large as that of West Virginia, and more than half the area of the entire Appalachian coal-field.

The third State in bituminous production is West Virginia, with an annual output of nearly 25,000,000 tons. Here the great Appalachian coal-field covers more area than in any other State. "The total area embraces about 16,000 square miles—more than 80 per cent. of the total bituminous areas of Ohio and Pennsylvania combined, 60 per cent. more than Pennsylvania alone, and 2000 square miles more than Kentucky and Tennessee combined."

The fourth coal-producing State in importance is Ohio, with a yearly production closely approximating to 24,000,000 tons. The coal-measures here are also part of the great Appalachian system, which extends over the eastern and southeastern portions of the State,—in all about 12,000 square miles.

The coals are all of the bituminous variety, and are known as "block" coal, "gas" coal, "cannel" coal, etc. These again are designated commercially as "Mahoning Valley" district, "Hocking Valley" district, "Salineville" district, according to the localities in which they are produced.

The "Block" coal of the "Mahoning" district is of special value for furnaces. In such use it is usually mixed with a little Connellsville (Pa.) coke. In the Hocking Valley and in Jackson County raw coal is used for the same purpose.

It is described as having a laminated structure, and is composed of alternate thin layers of vitreous, dull black coal and fibrous mineral charcoal. It splits readily into sheets and is with difficulty broken in the opposite direction. In burning it swells so little that its expansion is scarcely perceptible, does not change form, and never cokes or runs together. It is as pure as splint coal, is free from sulphur, and has the softness and combustibility of wood. Its effects in the iron furnace are said to exceed those of charcoal in the quantity and quality of iron produced.

In Columbiana County, in the region about Coalton, Jackson, and Wellston, a good article of coke is manufactured, which by mixing with a proportion of Connellsville coke is also used for furnace fuel.

From Jackson County comes the best coal for domestic purposes, and Belmont County produces a high grade of gas-coal. Gas is also made from the coals of the Mahoning and Hocking Valleys, Steubenville, and the Ohio River coals at Bellaire, Pomeroy, and Ironton.

According to Leslie, "cannel" coal is carbon nearly free from clay and sand, while "black slate" (which it greatly resembles) is charged with from thirty to fifty per cent. of carbonaceous matter.

"Apart from a chemical analysis, three convenient tests may be made by any one in doubt. The weight of black slate is greater than cannel, a splinter of it will not blaze like cannel, but merely glow. A heap of it on the ground will not make a fire readily, while a single lump of cannel laid on an ember will in a very short time entirely consume.

"Cannel, glance, splint, bony coal, black slate, are but so many gradations in a mixed and ever-varying proportionate deposit of carbon and sandy clay of an original vegetation, and the low current ooze of the shallow ocean in which it grew, or into which its leaves and twigs were floated in a condition of fine mechanical subdivision and solution. Where the vegetation was weak and the mud in excess, black slate was the deposit, but where the vegetation was densest and offered the most effectual barrier to the current and the influx of its mud, cannel coal was formed."

"The area underlaid by coal is about two-thirds of the local area of the State." The development of coal from this field has been extraordinary, increasing in thirty years from an annual output of only 672,000 tons.

These four States—Pennsylvania, Illinois, West Virginia, and Ohio—are the great coal-producing States of the Union. Together they produce more than twice as much coal as all of the other States combined.

But the bituminous tonnage from the other States is not to be despised, amounting, as it does, to something over 78,000,000 tons annually.

Of these, Alabama, with 10,000,000 tons annually, takes fifth place; Iowa, with 6,000,000 tons, sixth place, and then Maryland, Indiana, Colorado, Kentucky, and Missouri, in the order named, with annual tonnages ranging between 5,000,000 and 2,500,000 tons of coal each year.

Kansas, Wyoming, Tennessee, Washington, Indian Territory, Virginia, and Montana range relatively from an output of 5,000,000 tons to 1,000,000 tons a year, the other States in the Union producing annually less than 1,000,000 tons each.

The smaller tonnage of the latter States, it may be stated, is due to the fact that no necessity or market exists at present that would warrant more rapid development. The total coal production for the United States up to December 31, 1902, is estimated at 4,860,000,000 short tons. That means that a pyramid built of this material as high as

Pike's Peak (14,108 feet) would have for its base a rectangle 1.14 miles square. If the coal were spread out over the States of Rhode Island and Connecticut it would cover both of them a foot deep. The great store of bituminous coal is ready when the time comes for its production, and with this vast reserve at hand we need have no fear of the disturbing question which during the last fifty years of our progress has been so disquieting to our English friends. As early as 1859, Mr. Hull, of the English Government survey, measured up all the coal for the entire kingdom at 80,000,000,000 tons, but he went down 4000 feet, and also included about one-third "for extension beneath newer formations." Hoisting coal 4000 feet would be rather expensive mining,—twice as far as any of the present mines are worked; extension beneath the newer formations is uncertain; "two miles of heading *under the sea*" is significant of much worked-out territory on land; and it is not surprising to find Mr. Smyth, chief inspector, etc., dubiously hunting for "rays of light around it" by suggesting the washing of "dirty" coals, the working of 12- and 14-inch "thin veins," and the manufacture of patent fuel!

Let us look to it, however, that in our efforts towards development we follow not too closely in the footsteps of our English guides, lest the evil day come on us when we too will have to stop in our headlong and extravagant race for mere tonnage to take account of stock.

In 1865 the total coal tonnage of England reached 80,000,000 tons annually. To-day, they have added 165,000,000 tons *more* to that amount, with the United States 50,000,000 tons ahead! The extent of the anthracite field of Pennsylvania is known to an acre, with the contents calculated to a reasonable certainty. The famous Connellsville coking coal is confined within well-known lines. Is it too early to suggest that the day may not be far distant when the *cream* of our coal deposits will have disappeared?

PART II

DEVELOPMENT

CHAPTER IX.

SURFACE INDICATIONS.

WE can imagine our country before the "prospector" occupied the land. The discoveries of coal and other minerals were the happenings of accident, and often of ignorant observers who were unable to take advantage of the things revealed to them. We have heard the oft-repeated tale of the upturned tree in the forest with chunks of pure anthracite clinging—like potatoes—to the mass of roots, and the profound astonishment of the individual who first made the remarkable find. In like manner we have heard of the poverty-stricken farmer who built miles and miles of stone fence of purest coal, in dense ignorance of the blissful fact that his rocky old goat pasture was nothing more or less than a bank, "full forty feet deep," of the black diamonds. Also various other legends and folk-lore, handed down from one generation to another, until by mere persistence the naked fiction has been clothed with the mantle of truth and become a fact in the annals of history. That accidental discoveries have happened in the history of American coal is barely possible, but highly improbable. Geologists and the science of geology did not begin with the history of coal development in the New World, and the trained prospector at that time was abroad in the land, thoroughly equipped for his work, and inspired with enthusiasm at the magnitude of the task before him, with the experience of workers in older fields to guide and direct him.

Before the coal was actually discovered we find the writings of these old men of science full of information regarding the extent of the American coal-fields. They argued with exact precision and noted their conclusions with the confidence begot of knowledge, that the rock was of the age in which coal was formed, and from observation of the surface the coal was to be found as surely as the nut is contained in its prickly covering. It only remained for the discoverer to go to work at the place indicated by the geologist and dig or bore for the coal. The measure of his reward was generally conditioned by the quality of the coal discovered, for, while nearly all that tried found coal, it remained for the few to find the marketable coal of commerce. These few, yielding large returns, are the ones involved in the romantic mist of folk-lore. Pages could be filled with the interesting accounts of the various coal discoveries, pages of matter that have done service in each succeeding account since the beginning; but it is necessary to draw the line at romance or tradition with the accounts already given in the preceding chapters and continue the story in its various lines of development.

The geologist points out the path, the prospector, with the instinct of his profession, follows it until the coal is found. In his search no trifling appearance of the surface escapes his penetrating eye. Carefully he follows the winding course of the streams, the banks of the rivers, and dark ravines, industriously collecting evidence with which to convict Dame Nature of secreting treasures. The naked sides of beetling mountain-cliffs expose their seamy contours to the practical vision of the prospector in apparent frankness of expression, but he is too wary to trust entirely to appearances; the line of black smut, however, having once been found, points with unerring distinctness to the coal-seam beyond. The condition in which the coal-seams underlay the surface was for a long time misunderstood. In 1570, George Owen left in manuscript a "History of Pembrokeshire," in which he mentions the idea of an orderly arrangement of the coal strata, but he was evidently not aware of their uniform continuity in beds or seams, and improperly designates them as "veins." It is to the Welsh miners that we owe the word *gwythyen,* or vein, but "coal is never found issuing in veins from the interior of the planet," says Professor Lesley, "like gold and silver, nor filling irregular cross crevices in limestone, like lead; nor spread abroad in lakes of hardened lava, like basalt and greenstone; nor embedded in clay, crystallizing upward from the walls and bottoms of deep, wide fissures, as bunches of grapes, or in bundles of pipes like the hematite iron-ores; nor lying exposed upon the surface in blocks like native copper or meteoric iron; but always as a thin sheet or stratum, extending through the hills as far as the hills extend, and enclosed between similar sheets of other kinds of rock."

"There are, no doubt," continues Lesley, "few native business men of Philadelphia who cannot remember the panic occasioned by the news that the miners had reached the bottom of the Mauch Chunk Summit mine. . . . Men were terrified to learn that Mauch Chunk Mountain was not a solid mass of coal, but had yet to learn that one-sixth or eighth of the United States was underlaid by beds of it." Even at that time men were ignorant of the fact that coal is not contained in veins, but, on the contrary, in thin beds or seams, enclosed by many hundreds of feet of other rock.

By the coal prospector all evidences of the most trifling nature are carefully considered, the most minute observation given to the position of the rocks, their probable displacement by drift or glacial action, the positions of detached boulders and the causes of their probable removal from more distant localities.

He is also careful to consult the "oldest inhabitant" regarding all efforts made in the sinking of wells, the appearance of the river beds at periods of extreme low water, and the results of all quarrying and deep cuttings made for canals, roads, or railroads.

The geological "specimens" contained in almost every country house are given due consideration by the searcher for coal, and many a discovery made in ignorance by the unlettered forester or ploughman is made genuine by the decision of the geologist, without whose knowledge the "discovery" would have remained as though it had never been made. For if these specimens should contain any fossils,—the branching, fern-like *sphenopteris,* the regular impressions as though made by a seal of the *sigillaria,* the more ornate and graceful tracing of the *lepidodendron,* the broad leaf of the *neuropteris,* the star-like *asterophyllites,* or the pointed sections of the *calamites,*—he would know that the rock came from the typical coal-measures, and therefore he would have good prospects of finding coal in the neighborhood from whence the specimen came.

The black smut having led the prospector to the coal-seam beyond, he must needs be cautious lest the seam itself be not of the "crop coal" variety, which often extends over large areas, but which is so near the surface as to possess but little value. He should carefully note the angle or dip of the coal-seam, which is done by means of the clinometer, and by following the smut wherever discoverable locate on his map the probable position of the coal strata. If the exposures of coal are few, the streams and ravines are searched for the small pieces of coal—often like small round pebbles—and when found the search is continued up-stream until such fragments disappear. It is at this point that the coal-crop is close at hand, and more decisive measures are taken to locate its position. Selecting the most likely spot, a small square excavation is made on the hill-side, as if digging a well, and when the seam of coal is reached a point can then be selected on the same level with the coal-seam, and from it an open drift is dug at a sufficient grade to drain away all accumulating water. Should the surface be very abrupt and precipitous, the excavations are made directly into the coal-seam by a small drift or tunnel, which, if found to be in the right position, is afterwards enlarged and properly timbered, to be used as the main heading, or if not well located it can be used as a "monkey drift" for purposes of drainage, or for laying pipes, etc.

The surface indications in the bituminous regions are easily recognized by the trained prospector, and the configurations of the ground point with exactness to the position of the various coal-seams. These are plainly indicated in the "benches" or terraces of the hill-side, which usually occur at the outcrop, and are caused by the fact that the process of erosion works on the soft coal outcropping more easily and rapidly than upon the border enclosing rocks, thus producing the steps or "benches" in the hill-side.

Where the surface stream deposits a light yellowish covering over the stones and other objects in its course, we know that the water contains iron, and that it originates in a bed of coal.

When, after many "dry" holes have been dug and numerous trial ditches across the seamy old face of Nature have failed to disclose the coal beneath its surface, the exhilaration produced by the sudden discovery of a few small "kernels" of coal is one of the few genuine pleasures bestowed upon the prospector, but when the "blossom" appears the long, anxious days of worry and disappointment are forgotten in the keen delight of tracing it to the source. Williams, in his quaint style, has portrayed the pleasure attending these investigations,—when successful. "Of all branches of business," says he, "of all the experiments that a man of sensibility can be employed in or attend to, there is, perhaps, none so amusing, so engaging and delightful, as a successful trial upon the vestigia or appearances of a seam of coal or other mineral discoveries. When you are attending the people who are digging down or forward upon the vestige of the coal, and the indications are increasing and still growing better under your eye, the spirit of curiosity and attention is awakened, and all the powers of expectation are elevated in pleasing hopes of success, and when your wishes are at length actually crowned with success, when you have discovered a good coal of sufficient thickness, and that all circumstances are favorable, the heart then triumphs in the accomplishment of its wishes with solid and satisfactory joy. There is more rational delight, more substantial pleasure and happiness to be enjoyed in such scenes as this than in all the celebrated amusements which luxury invents and pursues."

The search for coal was not always confined to the patient efforts of the geologist and prospector laboriously working out each successive clew until success crowned their efforts. We read that the *virgula divinatorum,* or divining rod, is given credit for the discovery of coal in France. "This kind of coally stone," says Schoock after Guicciardin, "was discovered in the district of Liége, A.D. 1189, by a certain pilgrim, who, when he had pointed them out by a divining rod to a smith, suddenly disappeared; afterwards they began to be dug in great abundance." Morand tells us, in his "Mémoirs sur le Charbon de Terre," that the person who in Liége first discovered them is called "Prudhomme le Houilloux," or "le Veillard Charbonnier"—"Hullassus Plenevallium,"—that is, "the collier or blacksmith of Planevaux," a village within two leagues and a half of Liége.

It is only, however, under certain conditions that the coal-seams can be located by the topographical or surface indications. The great amount of drift comprised of soil or alluvial covering often completely hides the coal outcroppings and the positions of the coal strata from view. How often the discouraged prospector has wished for the faith that could move mountains, if only for one brief moment, so that he could view for an instant the uncovered and naked seams of coal! But no such strength being given us, the next step in the discovery of coal is by boring, as treated in the following chapter.

CHAPTER X.

BORING.

The prospector, not being blessed with a vision or instinct sufficiently strong to know the position of the coal-seam beyond the outcrop or face of his workings, if he would know what is beyond, must obtain that information by boring or drilling holes from the surface. In most well-regulated mines this is done at stated distances ahead of the workings, so that the operator may know what to expect and so make his plans accordingly.

In selecting spots for drilling, the probable course of the underneath tunnel or entry is first located on the surface, and on this line, at measured distances,—which are accurately noted in a record book,—the points are marked as suitable for drilling. The operation itself is simple or intricate, inexpensive or costly, as the case may be, depending on the depth of the cover overlying the coal-seam and the nature of the rock which the drill may penetrate. The most simple form of boring, and it may be added the most tedious and unsatisfactory, is with the "bit," which is nothing more than an iron chisel, similar to that used by stone-masons for drilling holes in stone, and used in the same manner,—alternately raised and dropped as the hole is driven deeper, and turned partly around with each drop, so as to cut a round hole and prevent the tool from wedging itself fast in the rock. As the work progresses sections of iron rods are fastened to the chisel until the required depth has been reached. In passing through the surface soil and clay an iron tube or casing—longer than the drill hole—is inserted, from the surface to the solid rock. When some depth has been reached by the bit and rods, they are withdrawn, and the broken bits of rock are taken from the hole by means of a "sludger," which is simply a short length of pipe fitted at the bottom with a foot-valve or trap, so that the churning of the "sludge" up and down will gather up the pieces of rock inside of the tube, which—the valve preventing them from falling out—are thus drawn to the surface, where they are carefully examined for indications of coal.

The rods are withdrawn from the hole by means of a rope attached to a pulley and derrick, and where the bit does not cut through any veins of water and the hole becomes dry, some water is poured into it as the work advances; this mixes with the fine bits of rock cut by the bit and facilitates the operations of the "sludger."

In drilling with the bit and rods a spring pole

—sometimes a young tree bent over—is used to lift the rods after each drop, an alternating motion up and down is done by hand-power, or a stirrup is attached for the driller to use his feet: hence the expression "kicking down" a hole. The holes drilled in this manner are usually from 2½ to 3 inches in diameter, and can be drilled from 20 to 30 feet in depth.

When the searcher for coal drills through the formations of more recent date than the coal-measures, he bores through the overlying strata of limestones, sandstones, clay, etc., until—when the coal-measures are reached—he taps the black shales, and often minute, thin seams of coal, called "riders," which are usually found in close proximity to the coal-seam itself. When the "rider" has been discovered the energy and confidence of the prospector are redoubled in the expectation of soon striking the coal, and when the drill drops into the soft, yielding bed of coal the task has been finished and the reward is commensurate with the thickness of the seam discovered and the quality of the coal. If the coal has been successfully reached by the common "spring pole," or the "bit and rods," that method of boring is quite as good as another, but many circumstances arise, such as increased depth of "cover," or the sudden disappearance of the seam from its natural position, when a more perfect specimen of the strata than can be obtained in the "sludge" will direct the experienced operator where to look for coal.

This specimen is obtained by means of a hollow cylindrical drill, furnished at the base or cutting end with a row of teeth like a saw, or with four or six bits. It is worked like a common auger and cuts a solid "core" or cylinder out of the rock as regular in shape as if cut by a lathe. By means of a spring grapnel, this core is brought to the surface and carefully examined and duly recorded. By this method, cores have been obtained in France and England at a depth considerably over 1500 feet and from 18 to 22 inches in diameter, while smaller diameters have been obtained in France at a depth of a trifle over 3000 feet by Herr Kind in his celebrated boring for coal at a place called *La Mouille louge,* between Creuzot and the Canal du Centre.

This interesting attempt is thus described by M. Simonin: "The boring at Mouille louge extended over four years, and was only stopped in 1857, at the enormous depth of 1006½ yards (920 metres), while the bore-hole, which at the outset had a diameter of $1\frac{2}{10}$ inches (30 centimetres), retained one of $\frac{5}{8}$ of an inch (16 centimetres). The coal-measures had not been passed through, and certain impressions of plants brought up by the boring tool, having been submitted to the examination of M. Adolphe Broquiart, were recognized by him as those of the *Ammearia longifolia,* one of the plants characteristic of the coal-measures. An accident, which it was impossible to foresee, unfortunately happened to arrest this boring, which is, perhaps, as deep as any which has ever been executed, and which has almost acquired a legendary interest among persons concerned in the sort of work in question.

"The boring tool got broken at the bottom of the bore-hole. This is a rare occurrence; no serious accident had happened before in that narrow opening, passing nearly vertically downward, and up and down which the chisels had to be raised and lowered in screwing and unscrewing the wooden rods one after another. Herr Kind, whose long and arduous career as a borer had been checkered by so many sorts of events, found his experience at fault this time. None of his grappling-irons could be made to take hold of the broken tool; the chisel, firmly lodged at the bottom of the bore-hole, resisted every attempt to withdraw it, and it became necessary, at the end of six months of fruitless efforts, to abandon the boring without a hope of ever renewing it."

In this country most of the borings are done with the diamond drill. In this apparatus the cutting edge of the tube or cylinder is supplied with small pieces of black diamonds or carbons, inserted in its outer or inner edge in place of the chisels, as before mentioned.

In this system of drilling, a "core" is obtained and the additional advantage gained of being able to drill holes in any direction, from vertical to horizontal. This drill is the invention of Hermann, and was patented by him in France, June 3, 1854. He states that he makes crystals or angular fragments of the black diamond useful in "working, turning, and polishing, etc., of hard stones, such as granite, porphyry, marbles, etc." The diamond is broken to obtain angular fragments, which are embedded by alloys in the metallic stock to form a cutting tool. Professor Rudolph Leschot, a French civil engineer, in 1860, and, later, Pihet, 1866, made some improvements on Hermann's invention.

The diamonds used resemble coal in appearance, though not so black, and are called "carbons" and "bort," the latter being set on the outside edge of the boring tube, and the former on the inside edge.

In this system perfect cores are obtained of the harder rocks, but when the coal itself is reached the rotary motion of the drill breaks off the core, which is often pulverized into fragments of fine coal, which, mixing with the water, is of no more value for examination when brought to the surface than the "sludge" obtained by the bit and rods.

The Chinese invented the system of boring by a rope instead of a rigid rod. By this method the cylindrical boring tool or bit is raised and lowered by a rope instead of sections of rods screwed together, and the weight of the tool itself falling to the bottom of the hole gives the necessary blow. In this way the tedious unscrewing of each section of rod, when withdrawing the "bit," is avoided, but the breaking of the rope is liable to leave the boring tool at the bottom of the hole.

The process of boring invented by Fauvelle, and described by him before the British Association in 1846, is given as follows: "His apparatus consists of a hollow boring rod, formed of wrought-iron tubes screwed end to end armed at the lower end with a hollow perforating tool. The upper end of the hollow rod is connected with a force-pump by a flexible tube. By means of the force-pump a current of water is sent down the rod into the bore-hole as it is sunk, and the water coming up again brings with it all the drilled particles, so that, except for the renewal of the perforating tools, the rods do not require to be elevated. M. Fauvelle found by experience that when he was passing through gravel or required to bring up considerable masses of broken off rock, it was better to inject the water by the bore-hole and let it rise through the hollow tube. In this way he has succeeded in raising stones 2½ inches long by 1¼ inches thick.'' From Collins we obtain an account (in 1867) of a very deep hole which was sunk at Sperenberg, near Berlin, and which reached the total depth of 4021 feet 8 inches. ''The first 956 feet were put down by manual labor and stiff rods, the remainder by means of ropes, to which were attached tools invented by Messrs. Fabian, Kind, and Zobee. The rocks bored through consisted of gypsum, anhydrite, soliferous marls, sandstones, and rock salt; much trouble was experienced from falls of rock into the hole. The upper part of the boring was 15 inches, the lower 12 inches in diameter. The whole work was accomplished within 2349 shifts of eight hours each, of which 1104 were expended in the actual boring and 1245 in raising and lowering the rods. An average speed of nearly two inches per hour was attained for the whole time, but the lower portion was executed rather quicker than this. The average cost was for labor six thalers, or a little more than $4.00, per foot; for labor, material, and interest on plant, about $10.00 per foot.''

Mr. Heinrich, in the *Engineering and Mining Journal* (1874), sums up boring as follows:

1. That manual labor is not advantageous for depths beyond 150 to 200 feet.

2. That a flat wire rope is better than rigid rods for depths beyond 200 feet.

3. That the system of Mather and Platt (*i.e.*, the cylinder bit armed with chisels) is preferable to the diamond drill for soft rocks.

4. That the diamond drill is most advantageous where the rocks are very hard, or where very accurate information is required.

5. That the small size of the diamond-drill hole renders tubing much less necessary in ordinary cases, but that such small holes are more difficult to tube when the necessity arises.

A shaft has been sunk near Parnschowitz, near Rybnik, in Silesia, to the depth of 2170 yards, or nearly a mile and a quarter. This is the deepest hole in the world, and was drilled by scientists to determine the nature of the under soil. The drill passed through eighty-three separate and distinct beds of coal during its transit to the bowels of the earth. The work was commenced in January, 1892. Unfortunately, the steel shaft of the diamond drill broke when the above-mentioned depth had been reached, and the work was abandoned, owing to the enormous cost of extracting the broken shaft. Over $20,000 had already been spent in the drilling operations.

CHAPTER XI.

DRIFTING.

The prospector having succeeded the geologist in determining first the existence and then the location of the coal-seam, the operator now takes charge of affairs and proceeds to open the mine. In this country, where the three professions are often combined in one individual, it frequently happens that this most important part of the business is, of necessity, carelessly done, with the usual result,—increased expense in getting out the coal and continual worry and annoyance, which a more intelligent beginning would have avoided. There is nothing more important in the successful mining of coal than the initial opening, and nothing in our country is more neglected in mining. In many of our bituminous districts the opening, as well as the prospecting, is left to the untrained judgment of an ordinary miner, who, in his place at coal-mining is thoroughly at home, but from the nature of his experience is not qualified to determine the nice points which should be considered by the mining engineer. To the judgment of the latter is left all questions of mining in European countries, owing in a great measure to the fact that the difficulties to be encountered in developing coal properties are so great that only men of technical knowledge, together with experience, are able to cope with them successfully.

In America, especially in the small flat seams of coal which crop out along the sides of the hills and mountains of Western Pennsylvania, the cost of opening a mine by the process of "drifting," as it is called, is so small that it is not thought necessary to consult an engineer as to the best manner of beginning operations. A man, a boy, and a mule often constitute the entire motive power, the effective energy, employed in many road-side "operations," but of sufficient American dignity to insure the man the distinguishing title of an "operator."

And this facility of development, resulting in multitudinous small openings by men of no experience or capital, is one of the fruitful sources of the extraordinary competition which has produced the inevitable result,—an enormous tonnage, far exceeding in quantity any possible demand that can be made on it, and at prices often below the actual cost of mining.

To this evil may also be ascribed the large amount of inferior coal sent to the market,—coal from the outcrop and coal from all parts of the seams, black bone, sulphur, binding slate, and other impurities, carelessly thrown into the cars and sent to tide-water at a price—at any price—to get rid of it.

And, unfortunately, this price being fixed by the inferior coals, the better grades mined by experienced miners and properly "prepared" before leaving the mines, at considerable cost, must be sacrificed to meet the market.

The sequel is monotonous in its sameness,—the small operator, with no capital, is sold out by the sheriff, and the large operator, with much capital, charges off a generous slice of his investment to the debit of profit and loss.

The tonnage, apparently unaffected by either experience, keeps on increasing, for it is in the coal business, like many others, where one man has tried and lost, another stands ready to take his place.

They do things differently in France. There the coal-seams lie at such an enormous depth they can only be reached by "shafting," and the position of a shaft is of such vital importance that a mistake in its location would bankrupt the projectors. To compensate for this increased cost of "opening," the trade conditions are just the reverse of ours. For while we cannot find a market for the twentieth part of the amount of coal we *could* produce, the French are obliged to import enough foreign coal to make up the balance of their requirements, after consuming all the native coal that can be mined.

These conditions necessarily mean much higher prices for coal than can be obtained in this country, and consequently a greater incentive for the investment of capital.

The "man, boy, and mule" outfit would be of no use in the European coal-fields, where, in order to reach a small seam of coal, deep shafts must first be sunk to a depth of 3400 feet! as at Viviers Reunis, near Gilly, in Belgium, or to 2500 feet, as has been done in several other cases.

The expense involved in sinking these shafts is very great,—depending, of course, on the nature of the strata to be penetrated,—the example just quoted being particularly costly because the overlying strata consisted of chalk, or cretaceous rock.

In England the expense of opening a mine by shafting, and before the coal was worked, amounted to $350,000. In another instance the sum of $500,000 was expended in sinking the shaft before the coal was reached. In the latter case, at the depth of 330 feet the pumps were kept busy discharging 3000 gallons of water per minute, for which a 200 horse-power engine was necessary. At 1000 feet the water increased, and a large sum of money was necessary to place metal tubing in the shaft to "stop back" the tremendous influx of water. Finally, at 1578 feet below the surface, the coal-seam was discovered. This shaft has since been sunk to a depth of 1800 feet, to reach a lower seam.

These cases are quoted to show the different conditions existing in Europe and in this country in the opening of a mine, conditions so preponderately in our favor that a comparison can scarcely be made; conditions that would give us the "markets of the world"—so dear to the heart of the free-trader—for our surplus coal, did not the great compensating law of nature fix our mines in the interior mountains, instead of along our seaboard, with an intervening distance of several hundred miles, for which the American operator must pay tribute to the transporting railroads.

As the centre of population, and with it the consumption of coal, moves slowly towards the interior, this matter will be adjusted with increased benefit to the operator, and the corresponding barrier of distance will intervene against the transportation of foreign coals from the seaboard to our interior cities.

That such importations have not already been made is due primarily to the tariff on bituminous coals, and to our cheap methods of opening and working our mines. For if, by reason of deep shafting and other causes peculiar to English mining, the American operator should be compelled to ask the same price as that obtained by the English colliery proprietors at the pit mouth, and the foreign coal was brought to our seaboard as ballast for vessels,—which has actually been done,—we would certainly lose our entire seaboard trade unless protected by the tariff.

Until our present upper seams are exhausted we need fear no such competition from transatlantic coals, but it behooves us to keep an eye on Nova Scotia, an English colony where coal can be mined as cheaply as in the United States, notwithstanding all reports to the contrary.

In America we employ four methods of opening a mine,—viz., the drift, the slope, the tunnel, and the shaft. These different methods are adopted according to the nature of the surface and the position of the coal-seams. The most easy and cheapest manner is the first, or the drift, but this can be done only where the coal-seam is nearly level and above the water line. The drift mine is very simple: it consists of a small opening, about six feet high and eight feet wide, "drifted" or driven into the coal-seam from the outcropping and making a small tunnel in the coal itself. The point selected for beginning the drift is at the lowest part of the outcrop. This is done so that any water met with in the mine will drain out of it, and also that the coal may be easily hauled on a down grade from the interior of the mine to "daylight." A property thus opened by drifting at the lowest part of the outcrop and progressing into the hill at a slightly ascending uniform grade is the cheapest and most favorable mine in which a miner can win the coal. This is called "taking the coal on the rise," and the reverse of this operation, that is, where the grade is slightly descending as the drift progresses, is called "taking the coal on the dip." In the first instance the mine is always dry and free from water, as it runs out of itself, while in the latter case the water is always ahead of the workings and just where it is the most troublesome, at the "face" or end of the drift or tunnel. Artificial means must then be devised to free the mine from water. This can be done by a siphon made of iron pipes, three or four inches in diameter, coupled together and forming a continuous line from the water at the lowest part, or "sump," in the mine to a point outside the mine and at a lower elevation than the sump. This pipe-line is fitted at both ends with stop-cocks or valves, and a small hand-pump is used to fill the pipe with water. When this has been done the valves are opened and a steady flow of water will continue through the pipes until the valves are closed or the water-supply exhausted.

But the coal-seams are not generally found in such advantageous positions, and it is becoming more apparent as our development continues and our upper seams are being worked out, that we must prepare ourselves for the problem of the future when the "drift" mine will be unknown, and the only manner of getting our coal will be by "shafting."

So far the widely-advertised "machinery" has done little for coal-mining beyond increasing the tonnage *and the cost,* both unwelcome changes in a market already overstocked, and the fact remains that in spite of "air cutters," electric haulage rope systems, and the like, the man, boy, and mule power—in a drift mine—is the cheapest of any, and the farther away we get from it the more expensive our mining becomes.

But, unfortunately, we must take the coal as we find it, and the circumstances are very rare where dame Nature is so obliging as to furnish opportunities for drift workings combined with proximity to the centres of consumption and a high-grade coal. In most cases we will have to consider "shafting" hereafter as the only way of reaching our coal-seams, and when that time arrives the work will have to be done by large corporations with ample capital, sufficient to cope with the difficulties which will naturally be presented.

And that these difficulties will be of considerable magnitude is evidenced in the sinking of a shaft recently in the bituminous regions of Pennsylvania, where at a depth of barely 300 feet the inflow of water became so great that it was found necessary to supply pumping machinery capable of raising 6000 gallons per minute. The energy required to work these operations will be not less than 1200 horse-power, involving an outlay of money far exceeding the capacity of any single coal operator. These troubles may be expected to occur in this country when we can no longer work our coal by drifts, and when that period arrives it will require all the sagacity and perseverance of the operators, together with the inventive power and skill of the American engineers, to overcome them. The cost of producing coal will certainly be increased to a point closely approximating the English article, and the question of protecting our home markets will be more than ever a subject for serious consideration, for all comparisons made between English and American coals must be calculated f. o. b. at tide-water, or the Atlantic seaboard; which comparison, even with our present cheap cost of mining, is in favor of the foreign coal by more than the entire duty.

CHAPTER XII.

OPENING A MINE.

From the explanations given in the preceding chapter it will readily be understood that drift workings are the cheapest and best way of opening a seam of coal, but the case seldom arises in these days to permit of that method being used. In the anthracite regions of Pennsylvania it may be said that the coal accessible by drift workings has practically been worked out, while in the bituminous regions the localities where such operations may be carried on are confined to the comparatively undeveloped regions, some distance from the main arteries of the coal trade,—those great coal-carrying railroads,—so that the cost of transportation is more than an offset to the cheapness of production.

We come now to the next best method of development,—the tunnel,—which is nothing more than a drift through the rock-measures, instead of through the coal itself. It is difficult to illustrate this without a diagram. In order to do so suppose the seam of coal contained in a hill, instead of lying flat and parallel to the horizon, to be inclined from the outcrop high up on the hill and pitching downward into and through the hill. The outcrop being too high, or possibly not exposed, a tunnel is driven into the side of the hill through the rock at water-level until the coal is reached; the coal is then mined and hauled out to the tipple through the tunnel, the length of which determines its desirability as the proper method to pursue.

The tunnel should have a descending grade towards the entrance to permit the exit of any accumulations of water.

Like the drift, the tunnel must be properly timbered at the entrance through the soft rock, and at such other points where by reason of poor roof it is deemed necessary.

By this method interior tunnels are often driven through the intervening rock from one coal-seam to another when both seams are slanting.

When the tunnel from the surface has been driven to the coal-seam, passages are opened along the "strike" of the seam at right angles to the tunnel, and the work of mining coal then begins.

Tunnels are not often used in these times, for the same reasons that apply to the working of drifts,—the absence of much coal in this country remaining above water-level,—if we except the small openings, amounting altogether to a considerable number, but the large tonnages in both anthracite and bituminous coals are coming to-day from slope and shaft mines, of which mention will be made.

Where the coal-seams crops out at the surface and is at an angle, as in the previous illustration, the most common way of mining the coal is by a slope, which is exactly similar in opening to a drift, inasmuch as the main gangway or entry is driven into the coal itself, but is not level, the drift following the dip of the coal downward or in a sloping direction into the hill: hence the term slope. When a suitable distance has been reached, gangways or headings are driven at right angles along the "strike" of the seam, and the mining of the coal begins at this point.

The "dip" of a coal-seam is its angle of inclination measured from a horizontal line. The "strike" is the direction of a horizontal line along or across the seam. It is always at right angles to the dip.

Where the dip of the coal is more than 15 or 20 degrees, the seams are usually worked by slopes. From Mr. Chance's report comes the following extract:

"Slopes are greatly preferred to shaft openings at all points in the anthracite regions where the coal is accessible along its outcrop. The usual practice is to sink the slope and its airway side by side, and at a depth of from one hundred to one hundred and ten yards on the bed to open out a 'lift' by driving gangways to the right and left. The breasts opened along these two gangways constitute the 'first lift.' This is often worked for several years before the slope is sunk to open a second lift, but it is now frequently the practice to continue the sinking without waiting until the coal on the upper level is nearly exhausted. When this is done, work on the slope is prosecuted at night, at least the raising of rock and lowering of supplies, so that this work does not interfere with mining and raising coal from the upper level.

"The 'second lift' is usually opened out at a depth of from 75 to 100 yards from the first lift.

"Sometimes three or four lifts are open at once, but there are few collieries mining coal from more than three lifts at the same time.

"In 'lift' mining the water is pumped from each of the different gangways, and at many collieries nearly all the water is caught on the first and second lifts, the lower levels being very dry. The surface water is often caught on the water-level, gangway, or drift, driven from the outcrop to the first lift and conveyed directly from the mine without pumping."

With the slope mine comes the introduction of power machinery, the angle of inclination being too great for the strength of the patient, hard-working mule. This useful animal is used along the inside galleries of the mine, but the loaded cars of coal, first being drawn by it to the foot of the slope, are then hauled up the slope itself by wire ropes connected to a winding-drum and hoisting-engine to the surface. Here Nature provides the means by which we are enabled to rob her, the coal under the boiler of the hoisting-engine providing the necessary power!

As before described, the drift or slope entries into the coal are available only when the outcrops of the coal-seams are accessible.

For opening the inclined seams the tunnel method may be used, but where the coal-seam is in a flat country and lying horizontally some distance below the surface, or, as is often the case, below water-level, the opening will have to be made by "shafting,"—that is, sinking a shaft or hole from the surface to the coal-seam below. As this is the most expensive method, it is also probably the most effective, enabling the operator to penetrate the very heart of the coal at once, and also permitting him, in some cases, to extend his workings in every direction.

In shaft workings there is no such thing as "crop coal" to be had; consequently a shaft operator has none of that stuff in the beginning to "work off" on the innocent and confiding customer. The first wagon-load of coal obtained from the bottom of a shaft is a fair sample of the contents of the mine, barring, of course, accidental circumstances, such as water, faults, clay veins, etc., which are liable to occur in all mines at any time,—drift, slope, tunnel, or shaft.

When a shaft is decided upon as the best method of developing a coal property, it is impossible to give the location of it too much skill and attention, as the success or failure of profitable after-workings depends on it entirely. Mr. Chance gives it as his opinion that "it is absolutely necessary to have all the geological information attainable represented on an accurate map, and one or two cross-sections constructed to show the geological structure." These must be verified by a series of bore-holes, as described in a preceding chapter.

The proper position of the shaft having been located on the ground, work is begun by sinking a square or rectangular hole through the surface-earth until the bed-rock is reached. This surface-earth does not often exceed a depth of over 20 feet, and must be kept from caving in during the progress of the work and thereafter by stout timbers framed together, or by a stone curbing, as in a well.

In Europe, the almost invariable custom is to sink the shafts in a circular form, but in America the square or rectangular shape is the method most employed. Other shapes have also been tried, including the elliptical and polygonal, but as neither of the latter shapes possesses any advantage over the square or circular, these two shapes are those in general use. It may be said of round shafts that they are the easier and cheaper mode of sinking, and are also better able to resist the pressure of loose and unstable ground, the pressure being equalized and better adapted for the introduction of metal lining known as "tubing." The square form, on the other hand, is more economical of space, every inch being occupied by the cages in the working shaft. Other considerations also govern the shape of the shaft, as, for example, the scarcity of timber or of suitable stone or bricks for curbing; where timber is plenty, as in our country, the square or rectangular shape is generally adopted.

The size of the shaft depends entirely on the use for which it is intended. The *width* is seldom over 12 feet; it is regulated by the length of the small mine cars in use in the mines; the *length* by the number of compartments intended to be used in its operation. A compartment is usually from 6 to 8 feet broad, so that an opening for a shaft with two compartments, the smallest in use, would measure 12 feet wide by 18 or 20 feet in length, the largest in use, of six compartments, measuring 12 feet in width by 52 feet in length.

The first sinking of the shaft through the surface soil and earth is made from 4 to 8 feet larger than the size of the shaft in the rock, in order to give room for the timber or stone curbing along its sides. This timber curbing is made of pieces a foot or more square firmly fastened together, and when the hard rock is reached is set firmly on it.

The excavating through the earth is done by a windlass, or the earth is shovelled on stages or platforms, and then carted or wheeled away. When the solid rock has been reached no further timbering is necessary until the sinking is completed. The depth to which the shaft is sunk depends, of course, on the position of the coal-seam. With us, it is seldom over 300 or 400 feet in the bituminous region,—insignificant as compared with European practice,—while the deepest shaft we have in the anthracite region is the Pottsville (Norwegian), which is nearly 1600 feet.

The size of this shaft, which is rectangular in shape, is about 14 feet by 16 feet in the rock, and the sinking was done by what is known as the "long-hole diamond drill process," described as follows: "Four drills were used, each boring a hole $1\frac{3}{4}$ inches in diameter and from 200 to 300 feet deep. Twenty-five holes were bored about

3 feet 3 inches apart in one direction and about 4 feet apart in the other direction.

"When completed, the holes were filled up with sand. The miners then commenced blasting by removing three or four feet of sand from the holes and firing them in groups.

"This process was continued until the bottom of the holes was reached, when the work of drilling recommenced. A central group of holes was always fired first, and the outside rows afterwards. The outside rows of holes squared up the shaft very nicely, so that but little trimming was needed, although many of the holes were not exactly perpendicular, and some were not straight." Where the holes can all be bored at one operation from the surface to the coal-bed, this process would seem to give very satisfactory results.

When the coal has been reached at the bottom of the shaft a "sump" is excavated on the dip or lower side in the coal. This sump catches all the water, which from it is pumped out to the surface. After the sump has been excavated, working gangways are driven right and left into the coal.

The *average* time required to sink a shaft, including timbering and all stoppages, is from 200 to 300 feet per year, although many shafts have been sunk at a much faster rate.

The use of steam-drills or drills worked by compressed air will facilitate the work through hard rock, but in shale, slate, and soft sandstone better time can be made by hand.

"The cost of sinking in *very hard rock* for rectangular shafts of an average cross-section is from $5.00 to $8.00 per cubic yard for shafts from 400 to 800 feet deep. The cost increases rapidly with the depth, and for shafts more than 800 feet deep the cost per cubic yard may approach $10.00.

"But in softer strata, especially shale and soft sandstone, shafts from 500 to 800 feet in depth have been sunk for much less. The average cost per cubic yard in such material ranges from $2.00 to $5.00."

Taking an average alternative of hard and soft rock, from $3.50 to $4.00 per cubic yard would be a fair average for sinking a shaft of ordinary depth and size.

The foregoing description of opening the coal-beds by "shafting" concludes the several methods in use in this country.

CHAPTER XIII.

GETTING THE COAL.

The production of coal in the United States requires a large army of men, no fewer than 485,000 being employed in and about the mines at the present time.

Of this vast body of workers, 145,000 are employed in the anthracite regions of Pennsylvania, while the remaining 340,000 are scattered over the other coal-producing States engaged in the mining of the various bituminous fuels.

It is creditable to our manhood that women were never employed as laborers in American mines, although such was the case in France and England for years, and in Scotland within the past sixty years women and children were employed to carry coals on their backs from the mines to the surface.

In the "History of Fossil Fuels" (1841) we find: "In the Scotch colliery of Gilmerton, in Mid Lothian, which is nearly 90 fathoms (540 feet) in depth, the coal, which is five feet thick, and lies at an angle of 40 degrees with the horizon, is borne *upon the backs of women and girls* from the various workings, in wicker creels, which are fitted to the back, and steadied by a leathern strap passing around the forehead. The regular load of a good bearer is 12 to 14 stones (*168 to 196 pounds!*) and the remuneration about one shilling (24 cents) per day. These bearers have for lights small oil-lamps hooked in the front of their caps; their dress the coarsest woollen; and they generally use a very short stick as a steadier to their precarious footing."

On the same page the author notices the killing of "three young women, sisters, by an explosion of fire-damp," in Staffordshire, England.

Twenty-five years later (1868) we learn from L. Simonin: "In France women no longer work in the mines; in England they work only on the surface, and in Belgium they are still employed, but such cases become every day more and more rare."

The early coal tonnages in the United States were produced by very crude and simple methods. When the coal outcropped on the hill-side the intelligent citizen merely took pick and shovel and filled his wheelbarrow with sufficient coal for his requirements, or if shafting was necessary he dug a well down to the coal-seam and hoisted his supply of coal with crank and windlass after the manner of "the old oaken bucket,"—digging another well when the first one became inconveniently wet.

To-day we do things somewhat differently, the getting of the coal forming, next to the location of the shaft, the most absorbing duties of the technical expert.

The "main entry" in a mine is laid out with the precision of a main avenue in one of our cities, and from it at right angles are driven the "headings" like so many cross streets, lined on either side with the "rooms" or daily workshops of the miners.

Here all day long they bend to the task of mining, each from four to five tons of coal daily, and be assured that it is no light task, but heavy, unremitting toil from early morning until the night.

Enough happiness can be found in the hazardous lives of the soldier and sailor—even in the hard life of a farm laborer—to call forth the song of a poet, but none have ventured to chant the praises of a miner's life. For him:

"Howe'er the daylight smiles, or night storms rave,
His dangerous labor, deeper than the grave;
Alike to him, whose taper's flickering ray,
Creates a dubious subterranean day.

"Or whether climbs the sun his noon-day track,
Or starless midnight reigns in coif of black;
Intrepid still though buried at his work,
Where ambushed deaths and hidden dangers lurk."

Few persons have the courage to descend a shaft into the coal-mines; the animal instinct is strong within us, and our natures revolt at the idea of creeping through tunnels and vaults hundreds of feet through the terrible darkness under ground.

What have we to say, then, for the courage of the brave fellows who continually work in the mines for their daily food and raiment?

Here is a miner, with his partner, or "butty," just entering the mines. Let us follow him and draw our conclusions afterwards. We are in one of the drift mines of the Pennsylvania bituminous region. The long, dark entry reaches away into the bowels of the earth lost in Stygian blackness. The little child's teapot of a lamp throws a flickering light from its position on his hat peak,—enough to show the low overhanging roof beams, bent here and there with significant emphasis of the superincumbent three or four hundred feet of surface.

Bending low to avoid collision with the overhanging mass, he moves swiftly along the narrow gangway with that peculiar crouching, loping movement of a miner. A hundred yards, three hundred, often a mile under ground before he comes to his "room." Here, in a space about eight yards wide and five feet high, he begins his work. His tools consist of several picks, a shovel, an auger, tamping bar and needle, oil, and powder can. It is too great a distance to return to daylight for dinner, so he brings it with him, in the familiar tin bucket.

The rumbling of the small mine cars, drawn by mules, is heard, and a car pushed into the room on temporary wooden rails is ready for filling with coal.

"With his pick he digs away at a space at the bottom of the seam, to accomplish which he must lie down on the floor of the mine while he works his arms, 'undercutting' the coal. This undercut slopes gradually downward, until he has undermined a space clear across the room, as far as he can reach under the coal with his pick.

"This done, he takes his long crank auger, places a small piece of board across his breast, against which to rest the end of the crank, and bores a hole into the top of the coal at an upward angle, taking care not to bore deeper than the undercut. Next he makes a cartridge by wrapping a piece of newspaper about a round stick the size of a broom-handle, which he withdraws, and the paper shell thus made is filled with blasting powder according to the desired size, usually six or seven inches in length.

"The cartridge is then stuck on to the point of the tamping needle, which is a slender-pointed rod of iron, five or six feet long, and forced into the hole with his tamping bar, which is a heavy iron rod with a head at one end through which a groove runs to fit the needle.

"The miner tamps in the cartridge with damp coal-dust as solidly as possible. The needle is then withdrawn, leaving a round hole leading to the powder in the cartridge.

"A lighted squib is thrust into the hole, and the miner seeks a place of safety. The squib is about the size of a slate-pencil, and acts very much as a "chaser" does in Fourth of July fireworks. The moment it begins to burn it rushes forward to the powder, where it explodes and sets off the blast.

"After the blast is exploded the miner waits until the smoke has cleared away, and then carefully examines the roof before re-entering his room, in order to avoid accidents.

"A single shot will sometimes dislodge a ton or two of coal, while often it has no effect at all, and is called a 'blind shot.' When the coal is knocked down the miner carefully shovels it into his car, saving the large lumps to pile around the edges, heaping the car as high as possible.

"He then shoves it out to the main heading, where the drivers with the mules couple the cars together in strings and haul them out."

For this service the miner earns from 55 to 60 cents a net ton. In this matter he is his own "boss," as he contracts with the company or operator at so much a ton delivered on the mine cars. These cars are small wooden affairs on four iron wheels, from six to eight feet long, between two and three feet high, and of about one ton capacity. They are narrow on the bottom, but flare out at the sides so that the top is about double the width of the bottom. A track of wooden rails must be laid for the cars to run on from all of the rooms to the main heading tracks, where the rails are of iron or steel. Along this main heading the driver and mules collect the cars at each room and haul them out to the colliery or "tipple," where they are dumped into the long railroad cars and from there shipped to the consumer, wherever he may be.

The main heading must be made high enough for the mules to walk, and where the coal is only three feet in thickness nearly as much more "bottom," which is composed of hard fire-clay, must be taken up, or the "roof," which is generally composed of hard rock, must be taken down. Five and a half feet from the top of the car-rail to the roof is the measurement for making headings into which the mules are to be driven. If the coal-seam is but 3 feet thick, this leaves 2½ feet of "dead work" for the operator to pay. In the rooms where the miners work, the bottom is not required to be taken up, as the cars have to be shoved by hand to the main heading where the mules are.

In driving headings and air-courses and turning-rooms, the work is paid for by the operator by the lineal yard, in addition to the ton rates for the coal they take out in the process of advancement.

In mining the coal the miner who is doing the work by contract furnishes his own tools and material, and, of course, must keep them in order at his own expense, for which he usually pays 50 cents per month; he pays $1.00 a month to the mine physician if he is married and 50 cents a month if single, and contributes his quota to pay a check-weighman $2.00 a day to watch the weighing of the coal and see that correct weights are given and the scales properly adjusted. A miner will burn on an average, if work is at all steady, a gallon and a half of lard oil per month, costing 50 cents a gallon, and consume a keg of blasting powder, the cost of which is $1.50. With renewals of tools, lamp-wicking, squibs for igniting blasts, and other sundries, it is estimated that the mining expenses, outside of blacksmithing, check-weighman's pay, and physician's bill, will average $3.00 a month. The other requirements will bring his expenses up to at least $5.00 a month. These expenses, as well as his house rent and "company store bill," are deducted from the earnings of each miner before he is paid any money. At the present scale rate of 66 cents a gross ton for mining coal three feet and over in height, and 70 cents for coal under three feet, *together with the marked improvement in the mining industry,* the miner is, indeed, unfortunate who receives a "snake statement" instead of a pay envelope when pay-day comes around. A "snake statement" is where a miner's indebtedness exceeds his earnings, and a crooked line is drawn from the figures of the balance owed by him to the credit given.

The foregoing description of the daily work of a miner in the ordinary drift mines in the bituminous region of Central Pennsylvania is taken from the miner's point of view. To add to its value I propose to continue, with the same minute accuracy, a faithful recital of the expenses incurred in operating the mine from the operators' stand-point and from information obtained from them. In this way only can the "story" be made complete.

When the miner loads the coal in his room he is done with it. For that he receives, say, 66 cents a ton of 2240 pounds, and mines but four tons daily, a very small tonnage for a good miner in four feet of coal.

From this point the operator pays all other expenses necessary in production.

1. For the land, or royalty to the owner.
2. For opening, and outside improvements.
3. Raising coal to surface and hauling.
4. All "dead work," headings, and air-courses.
5. Superintendence or management and sales.

These expenses must all be paid before an operator can be said to have made a profit; for when the coal is exhausted the "plant" is of no value whatever. For this reason, if an operator owns the land in fee, he must put by so much per ton into a "sinking fund" to pay its first cost, or if he does not own it he must pay an equal or even greater amount for "royalty" to the owner.

In the books of a well-located "drift" colliery, which, as has been explained, is the cheapest method of mining, the following amounts were found nearly constant during a year's workings, in which time about 50,000 tons of coal were produced from a 5-foot bituminous seam. If a larger tonnage had been made, the items known as "fixed charges" would have been somewhat less:

Royalty per ton of 2240 pounds	12
Five per cent. interest on improvements, per ton	5
Hauling and dumping coals, per ton	10
Dead work, headings, and air-courses, per ton	6
Superintendence, per ton	3
Selling and office expenses, per ton	4
Total	40

Total expenses paid by the operator, 40 cents per gross ton, to which must be added the contract price paid the miner of 66 cents per ton, or a total cost of $1.06 per gross ton of 2240 pounds, without adding anything to the sinking fund.

This same coal was sold during the year in question at an average price of $1.10 per gross ton on cars at the mines, or 4 cents per ton more than the cost.

To such a condition has the mining of bituminous coal in the United States reached during the year just passed that few operators, and those only who own the land or who possess exceptionally good facilities for producing a large tonnage at a minimum of cost, could declare a profit of five cents per ton on their total output.

We now have a complete account of the production of coal from the miners' and the operators' stand-points. The results to both are obvious.

Seventy years ago Professor Bakewell wrote: "The coal (in America) is pure and lies above the beds of the rivers, *and costs about twenty cents per ton to quarry it.*"

With the *cost* of coal at 20 cents per ton it would be an interesting calculation to figure the proportionate rate per ton to be paid the miner. Of course, it is simply a pleasant little fiction, such as "professors" indulge in from the comfortable depths of a library chair. But, unfortunately, when taken seriously by our Representatives in Congress in their oratorical flights describing our coal-fields as "the cheapest production on the face of the earth," such statements convey an erroneous impression.

If our coal is to be sold at a reasonable profit to the operators, after paying a fair price to the miners, our increasing cost of production must soon approach the cost of English coals at the pit mouth, otherwise we will continue—as we are now doing—to sell our coal at an average of 50 cents a ton less than the English coals, with no profit to the operator and corresponding poverty to the miner.

There is no doubt whatever that American coals are selling at the pit mouth cheaper than at any place in the world, but the price paid by the miner and operator for occupying so distinguished and dangerous a position is misery to one and ruin to the other.

In Great Britain the average price realized at the pit mouth is considerably greater than that received for the same kind of coal mined in Pennsylvania. This is the result of British wisdom,—the operators are not mining simply for pastime.

In America the "hustling" methods employed by operators and their sales-agents to make tonnage, irrespective of profit, results, invariably, in the utter demoralization of prices. When this occurs—usually once a year—the only remedy that can be suggested by the operators is a reduction of wages. The result is uniformly disappointing to both operator and miner: to the former, who is obliged to give the full amount of the reduction to his customer, and to the miner, who suffers privation in lower earnings.

The reduction of wages is no remedy for financial distress in the coal business of this country. It is safe to state that five-sixths of all our coal is sold to large transporting and manufacturing corporations, who are not entitled to increased profits at the expense of the hard-earned miners' wages. The present duty on coal is sufficiently large to prohibit foreign competition, and the business should be managed so that our prices approximate more closely those of imported coals.

These are the facts. Our large production, of course, is the first cause of such a condition of affairs, and the remedy seems to be in its curtailment. How this can be effected is a matter for serious thought worthy of the brightest intellects in the coal trade. In the mean time it would be wise for our men of national affairs to study well the situation and to disabuse their minds of the fallacy that the operators are making money, the railroads likewise, the miners happy, and everything prosperous with American coals, "the cheapest on the face of the earth."

It is unwise, to use a mild term, to lower our prices received for coal so far below the English prices, for, with the facts just presented, they must be realizing a handsome profit, while we are simply giving our coal away.

CHAPTER XIV.

AIR AND GASES.

Having given some accounts in a previous chapter of the daily life of the American miner under conditions most favorable for him in getting the coal, it is now proper to note the principal causes tending to frustrate his efforts and in many cases to balk his most strenuous exertions or frustrate his best-laid plans.

The causes most contributing to his discomfiture in this direction, and, unfortunately, often attended with loss of precious human lives, as well as money, are involved in the presence or absence, as the case may be, of gas and water. In the former term is included the air or atmosphere, which itself is a gas, or rather a mechanical mixture of gases in combination, nicely proportioned by an overruling Providence to suit the lungs of human beings and sufficient for their life support.

When a sufficient amount of this mixture of gases, or atmospheric air, is found in the mines, then the question of ventilation has no bearing on the work of the miner, and he pursues his arduous task underground with the same freedom of movement as the laborers in the field, who inhale deep draughts of its life-giving properties under a blue sky.

This air, or atmosphere, envelops the earth like a mantle or covering, about 45 miles in thickness; enough, one would suppose, to supply each living creature upon the globe with all that is required; but the miner is under the earth, and in his progress under ground he is constantly boring into the crevices and fissures in the coal and rock, which give forth gases that will not support life; many, in fact, that will extinguish it.

As these occluded gases are released from the rock and mingle with the air of the mine they destroy the nice proportion necessary for breathing humanity, and by their additional weight render the air foul, and, as we say, poisonous.

The air in a mine, even with the admixture of the occluded gases referred to, is never the same naturally as that on the surface. Here the air passes down the slope or shaft, or into the drift mouth, and thence along the various entries and cross cuts, as water is conveyed through pipes, sometimes sluggishly and then more rapidly, according to the energy applied in its transportation from the surface.

This energy, primarily, is nothing more nor less than the difference in temperature between the surface and the interior of the mines. We know by experience that all gases expand on the application of heat, and become lighter as they grow warmer. If, therefore, we have a temperature high in one place and low in another, the tendency of the warm air is to rise, being lighter, and of the cold air to rush in and take its place, being heavier.

Their action on the surface causes the movement we call "wind," and to produce one of 20 miles an hour velocity it is only necessary to have a pressure of one pound per square foot.

It is different underground. Here the air, following through the many devious windings of the workings, is retarded in its progress by rubbing against the jagged, uneven sides and roof, and meets with many obstructions in its flow by reason of the necessary timbers, the passing to and fro of mine wagons and mules, and other obstructions.

These all cause friction, and this friction is of such moment that underground a pressure twenty times as great as that on the surface is required to produce a current of air in the workings equal to that of the velocity of the wind above-ground. It will readily be seen, therefore, that merely the difference of temperatures, or what is known as natural ventilation, will require a marked difference to be available. We know by experiment that as we descend into the earth the temperature increases—that is, it becomes warmer—until we reach a depth of 90 feet. At this depth, the varying degrees of surface heat in summer and cold in winter have no effect on the miner, the temperature of the mines being always the same,—usually about 60° Fahrenheit.

As we proceed to go lower into the earth we find the temperature increasing at the rate of one degree Fahrenheit for each 75 feet in depth.

In the extremes of summer and winter seasons we have, therefore, a considerable difference in temperatures between the air in the workings and the air on the surface,—sometimes as much as 50 or 60 degrees.

These differences, as before explained, produce the necessary energy to cause a lively movement of air through the mines, greater during the extreme heat of summer and cold of winter, and more feeble as the thermometer approaches the mark which indicates to us, who are not in the mines, an average pleasant temperature.

This natural ventilation might, in most cases, be sufficient, if there were no other influences vitiating the air of the mines. These have been mentioned as occluded gases.

In the first four chapters I have explained the origin of coal, including the growth and decay of vast quantities of vegetable matter, covered in course of time with deposits of mud, sand, and gravel. This decay or putrefaction, continuing under the heavy mass of covering, produced an enormous amount of gases, which, having no means of escape, are imprisoned in the coal-seams, awaiting the miner's pick and drill to set them free. When this is done, either by accident or design, they frequently burst forth with great force. These deleterious gases are commonly known as marsh gas and fire-damp, and, weighing but about half as much as the atmosphere, are usually found in the holes and fissures of the mine roof.

But, even though no large body of gas should be suddenly liberated from the workings, the coal itself is full of minute pores or cellular structures, through which the gas is constantly bubbling and oozing into the rooms and gangways of the mines, sometimes under a great pressure.

When this gas has been liberated and mixes with the air in certain proportions, it becomes dangerously explosive, and, under the name of "fire-damp," has ended the earthly life of many a poor miner.

Another less common but equally deadly enemy to ventilation is the gas known as carbonic oxide. One-half of one per cent. of this insidious gas in the atmosphere is sufficient to cause death. It is always present *after* an explosion from fire-damp, and for this reason it is frequently called "after-damp," but incorrectly, as after-damp has been found to be a mixture of several gases. It is owing to the presence of carbonic oxide, however, that after-damp becomes so fatal. Unlike other gases, its proximity cannot be detected by the ordinary method of testing with lamps, miners having been found dead with their lamps burning brightly beside them; others in a sitting position, without evidences of struggle or pain of any kind, having found death instantly.

An old writer pathetically describes the effects of this gas: "At one time an odor of the most fragrant kind—a faint smell of violets—is diffused through the mine, resembling the scent of sweet flowers; and while the miner is inhaling the balmy gale, he is suddenly struck down and expires in the midst of his fancied enjoyment; at another, it comes in the form of a globe of air enclosed in a filmy case, and while he is gazing on the light and beautiful object floating along and is tempted to take it in his hand, it suddenly explodes and destroys him and his companions in an instant."

Carbonic oxide is the result of imperfect combustion. It is often called "white-damp," and has no color, taste, or smell beyond the faint fragrance of flowers, and, fortunately, is not often present, excepting in after-damp.

It can be seen burning, in combination with oxygen, at any time by the inquisitive reader, if he will note the little blue flame dancing over a fire of red-hot coals in his library or furnace fire.

Another more common gas to be met with in our mines, and one very easily detected, is carbonic acid gas. Being heavier than air, it is always found in a layer along the floor. It is present in the gases occluded from the coal-seams, and is also produced by combustion. It is known as "choke-damp," probably because it chokes or suffocates the victim, as water causes death by drowning. It is not known what percentage of this gas, mixed with the atmosphere, is necessary to cause death, but in experiments made with animals as high as 30 per cent. has been used without extinguishing life. The exhalations of men and mules and the burning lamps of the miners, all tend to produce this gas, but as from 10 to 15 per cent. of it can be present in the air we breathe, without serious inconvenience, beyond a dull headache or nausea, it is not particularly dangerous, unless the warnings are ignored and one should deliberately remain in it. In that case he would die of suffocation, as a person will in drowning. This gas is more frequently found in old workings, and can be detected by the feeble flame of the lamp. A light plunged into the pure gas would be instantly extinguished.

Sulphuretted hydrogen is another gas met with in old workings; the disagreeable smell of rotten eggs is sufficient evidence of its proximity. About 3 per cent. of this gas mixed with the atmosphere is all that is necessary to cause death.

These are the most common of the ever-present poisonous impurities tending to vitiate the current of pure air which are met with underground, but which present no danger to those working on the surface.

If we had the power to detect the presence of these insidious foes, we might save many lives, but the methods now employed for this purpose are crude and even dangerous.

An authority states: "We have no simple means of quickly detecting the presence of 'white-damp;' its presence is usually only detected by its dreadful effects.

"The method of detecting the presence and determining the amount of 'fire-damp,' commonly known as 'trying the gas,' with a lamp, is always accompanied by more or less danger, but no more simple means has as yet been devised. Some miners think they can always *smell* the gas when present in notable amount, and they are doubtless right, but there are comparatively few men with sufficiently delicate olfactory organs to detect this gas owing to the presence of other gases with which it is mixed. Others think they can detect it by a feeling of dampness or coolness upon entering into a mixture of the gas; others tell its presence by the 'tink' or sound of the gauze (*i.e.*, around their lamps); but it is evident that none of these methods are trustworthy, because they all depend upon the extreme delicacy of some sense,—smelling, feeling, hearing."

But if we are unable to prevent the contamination of the air, or to detect the presence of these lurking enemies, we can in a measure neutralize their vicious energy by increasing the supply of pure, wholesome air, the natural antidote to all these noxious vapors. We accomplish this by means of artificial ventilation and increase the current of air passing through the mines by forcing a supply far in excess of the actual requirements. This we do in America by one of two methods,—a furnace or a fan.

The first method and the oldest is very simple. A large fire is maintained at the bottom of the air-shaft, and the heated column of air being lighter produces the necessary ventilation through the various rooms in the mines,—exactly as our rooms are ventilated by the familiar open fireplaces, the chimney in our dwellings corresponding to the "uptake" or air-shaft and the open door of the room to the drift mouth or other mine opening. By an arrangement of trap-doors or stoppings (first suggested by Mr. Spedding, of Whitehaven, in England) the current of air is forced through all the passages and rooms in the mines, thereby preventing the accumulations of dangerous gases.

The second method—a fan—is one now in general use in this country in mines of any considerable size or importance. By the rapid revolutions of this machine, which is run by an engine, a large amount of air is forced *down* the air-shaft and into the workings at a high velocity.

In England fans are also in general use, but their operation is reversed, the machinery being so arranged as to exhaust or draw the air *up* the air-shaft and with it the obnoxious gases. The various methods employed have certain advantages; all are employed for the same purpose,—the constant supply of fresh air to the hard-working miner underground. The subject of mine ventilation is a formidable one to the most skilful expert, and our technical literature teems with pages of matter describing every imaginable way of conducting the air current through the mines.

Notwithstanding all our boasted ingenuity and invention, explosions of fire-damp will occur, and "then the whole mine is instantly illuminated with the most brilliant lightning; the expanded fluid drives before it a roaring whirlwind of flaming air, which tears up everything in its progress, scorching some of the miners to a cinder, burying others under enormous heaps of ruins shaken from the roof; and, thundering to the shaft, wastes its volcanic fury in a discharge of thick clouds of coal-dust, stones, and timber." I could expand this chapter with the oft-repeated tales of accidents that have happened from the deadly gases of the mines or other causes, but such harrowing recitals only excite our pity and are not instructive. It is sufficiently sad to state that statistics show that for every 100,000 tons of coal mined in our country one poor miner is killed by accident.

CHAPTER XV.

HAULING TO THE SURFACE.

The miner having put the coal into the small mine wagons,—or "tubs," as they are called in England,—it is now the duty of the operator to take it from the miner's room underground, and haul it to the surface. The various methods in use for this purpose come under the general term in mining phraseology of "haulage," and right here, be it said, for the benefit of young or inexperienced operators,—if any such there be,—is the crucial point in mining coal: the part of the operation which will show a profit or loss in proportion to the knowledge and skill displayed by the man in charge.

Coal is a bulky, unwieldy mass to handle, and care must be taken to avoid handling it. This seems an absurd statement to make in a chapter devoted to haulage, but it is nevertheless a proper one when we consider the subject. The miner having been paid his contract price for loading the coal into wagons, it is the operator's business to arrange for the transportation of that wagon-load of coal along the various entries of the mines and thence to the railroad cars or vessels, without unloading it; for it is evident that a transfer of the coal from one wagon to another, or to a common receptacle or heap, and thence into wagons or cars again, can only be done by labor, and labor costs money. Nor is this the only objection to rehandling. Coal is friable and easily broken, and each transfer produces slack, and deteriorates the quality to such an extent that many of the softer coals are rendered unmarketable.

"In the olden times," says Mr. Hughes in his admirable treatise on English mining, "carrying the mineral on the shoulders of men *or women* was the method *universally* employed, and is still carried out in places *where civilization is imperfect.*" He then adds, with considerable ingenuousness, "The practice is, however, adopted in one instance in our own country, where the conditions are such that any other system would be impracticable,—viz., the ironstone mines of the Forest of Dean."

This system of "hauling" was followed by one equally as barbarous, and consisted of such slavish labor that the wonder is how it could have been carried on so long. The description by Simonin is so graphic that I have taken it entire:

"When the coal was cut away the 'putter' (*porteur*) or bearer came and conveyed it along the face of the workings to the better roads, either in bags, which he carried on his back, or on small sledges or trams (*wagons*), the rope of which passed between his legs and was fastened to his waist. Half naked, doubled up, and leaning on a staff, the 'putter' went panting along doing this work of a slave and often climbed to the surface, with the sack on his back, up an inclined road. Then he went down again to repeat the same task afresh, like a new Sisyphus, and so on, from morning to night."

This system was in force in the coal-mines of the Bouches-du-Rhone, near Aix, a few years ago (1860), having been first adopted towards the middle of the eighteenth century, when the mines in question were originally worked for the use of the soap-works at Marseilles.

The fathers taught their children, for youth and vigor were required for such labors as these. The wagon, which was very low and of a triangular shape, ran on three little wheels, one being placed at each angle. On the frame, consisting of some rough planks, rush baskets (*couffins*) full of coal were placed. The wagon itself was drawn by a boy to the main level, where the baskets were emptied into other wagons.

This was also the system used in many of the English and Scotch mines. The chain used for hauling the mine wagon passed between the boy's legs and was then hooked into an iron ring, which was attached to a leather belt around his waist. In this painful harness the boys strained and pulled the heavy wagons along the gangways, using both hands and feet like an animal, or, as we say, "going on all fours."

Thankfully I write such systems of haulage are not in use in America and never have been. Unless I greatly misunderstand the nature of my countrymen, the mines where "any other system would be impracticable" would remain as virgin soil until a more servile race took possession.

Under our laws no child or woman is allowed to work in the mines, and the men's labor, hard as it is, has nothing in it to detract from their dignity or manhood.

With the introduction of horses into the European mines, the heavy part of the hauling was done by them, and the man labor was confined to pulling the wagons from the rooms to the main gangway, where they were made up into trains or "trips" and hauled to the foot of the shaft, or, in the case of drift mines, to the surface by horses. In America, horses are seldom used for this purpose, the preference being given to the humble, patient, long-suffering mule. This sagacious creature is first led into the mines blindfolded, and a leather bonnet is sometimes put on its head to prevent injury from the low roof and timbers; the ears of the animal are not considered. In a few days' time the mule has been initiated and can find its way along the darkest gangway with the certain instinct of its kind. From that time it becomes a recognized part of the *personnel* of the mines, first being given a suitable name, which, according to the fancy and disposition of the driver, will range from homely "Pete" to the more sprightly "Nancy."

With the introduction of horses, came also the iron tramway or railroad, and it may be interesting to the reader to note the fact that our immense system of transportation by rail had its origin in the first rails made of iron in the year 1767, at Colebrookdale, in Shropshire, England. A writer in 1676 describes the old wooden railways as follows: "The manner of the carriage is by laying rails of timber from the colliery down to the river, exactly straight and parallel, and bulky carts are made with rowlets, fitting these rails, whereby the carriage is so easy that one horse will draw down four or five chaldron of coals, and is an immense benefit to the coal merchants." In situations where these roads were inclined, and particularly where plated with iron, no horse was required to draw the wagons, as without such aid they ran along very readily "and sometimes with such rapidity that a piece of wood, called a tiller, is obliged to be applied to one wheel and pressed thereon by the weight of the attendant, who sits on it to retard the motion, by the friction of which the tiller and sometimes the carriage is set on fire!" A marvellous speed, certainly, for a loaded coal-wagon on wooden rails, 240 years ago. If the writer may be allowed to use an "Americanism" or slang, "we are not in it," as regards speed in hauling, with those old English colliers when they struck a "down grade."

All of our mines are equipped with steel rails of the T pattern, of a section weighing from 16 to 40 pounds per yard, and are laid to a gauge of 3 or 3½ feet apart. They are connected at the joints with two iron straps, one on each side of the rail and bolted through like a splice. These straps are called "fish-bars."

Where timber is plenty, as in this country, the rails are laid on cross timbers, called "sills," but in England they use for this purpose a "sleeper," made of light steel and weighing about 14 pounds each. Sometimes the steel is corrugated to increase its strength.

The main roads in a mine are laid out in much the same way as a railroad on the surface, and much care is taken to have the rails laid evenly, and to arrange the line with as low grades as possible; at convenient places turnouts and sidings are placed, so that the loaded wagons going out can pass the empty ones coming in.

The wagons in which the coal is hauled over the mine roads are small wooden affairs, and their uses have been described in a preceding chapter. In our mines we make them almost invariably of oak, of good seasoning; often of lighter wood. The wagons are frequently made of iron or steel in Europe, but for many reasons—chiefly the first cost and ease of repairing—the wooden wagons are the best. Unlike our common railroad car, the wheels of a mine wagon revolve loosely on a fixed axle, as in an ordinary road wagon, a clumsy, unmechanical arrangement, which we inherited from our forefathers, and which we continue to use for no other known reason. It is impossible to keep the wheels at gauge, and they continue to "wabble" over the roads as they have wabbled for centuries. The day may come when the economy will be apparent of constructing a firm, solid road-bed, and wagons with wheels fixed to the axles.

It is not in the scope of this chapter to go into details regarding the various and complicated methods of hauling by ropes or chains. For these the reader is referred to the many excellent text-books treating of the subject. It will be sufficient to call attention briefly to the several methods in use,—viz.:

Self-acting planes are simply inclines, of sufficient grade, where the loaded wagons attached to one end of a rope run down hill and haul up the empty wagons, which are fastened to the other end of the same rope. At the head of the incline, or at the top of the hill, a "sheave" or wheel is fixed, around which the rope passes with one or two hitches to prevent slipping; sometimes a smaller wheel is used in connection with the large one to increase the friction. With this arrangement, a double track is laid on the hill: one for the loaded wagons to run down and the other for the empty wagons to run up.

Direct Haulage.—An arrangement by which the empty wagons running down-hill into the workings with sufficient energy to pull a haulage-rope in with them are then hauled out loaded.

Tail-Rope.—Where, the hill not being sufficiently steep, there is not enough energy in the moving empty wagons to pull in the haulage-rope. In this case, a second or tail-rope of smaller diameter is used to pull the empty wagons and the attached haulage-rope into the workings.

Endless Chain.—As its name implies, an endless chain, passing from the engine along one side of the road around a pulley at the far end and back again on the other side of the road. The empty wagons are attached to one side of the chain by various kinds of clips or hooks and are hauled *into* the mine. The loaded wagons are attached to the other side of the chain and are hauled *out* of the mine. This sytem is also called the *endless rope,* where a rope is used instead of a chain.

In America the tail-rope is the one in most favor, where such haulage is possible.

Returning to the mule-power, the results are: "The average useful effect of one mule may be considered to range from 20 to 50 tons hauled one mile per day. On roads of average grade, we may assume the useful effect of 40 tons. If the car weighs 1 ton, and carries 2 tons of coal, the useful effect in *tons of coal* is 20 tons hauled 1 mile per day by each mule. This may be considered to fairly represent the daily performance of an ordinary mine mule, when averaged throughout the year. In hauling a " trip" of mine wagons, the mules are hitched tandem,—one ahead of the other, three, four, or five together,—the leading mule carrying a small miner's lamp attached to his head or hung to his collar."

Another mode of haulage is by means of small mine locomotives, weighing from 6 to 10 tons, but they can only be used in mines that are free from gases, and where there is plenty of air with quick ventilation. The danger from fire is also too great to overcome the advantage they possess in increased speed. This objection has stimulated the efforts of inventors to replace the boiler by an air receiver. The new locomotives are approximately 10 feet 5½ inches long, 5 feet 8 inches wide, and 4 feet 5 inches high, and weigh 10,000 pounds. It will readily be seen from these figures that they are adapted for running in very small openings. The cylinders are 5 feet 10 inches, and the driving-wheels, of which there are four, are 23 inches in diameter. The storage-tank has a capacity of 47 cubic feet of air and a working-pressure of 535 pounds per square inch, and there is also an auxiliary reservoir. The locomotive main tank is designed for 600 pounds, but the working-pressure for the service intended is about 535 pounds. A 3-stage compressor is used, pumping into a 3-inch pipe-line, which serves to connect the compressor to the most convenient point of charging the motors, and also acts as an air-reservoir, the compressor and pipe-line being competent to withstand a pressure of 850 pounds.

These locomotives, which take the place of mules, are to be used in side entries and in making up trains in the rooms of the mine, and delivering the trains to the main entry, where they are handled by steam locomotives. The average length of each side entry is 4500 feet, with grades of $1\frac{3}{4}$ per cent. in favor of the loaded cars. The gauge of the track is 3 feet 8 inches, the weight of the rails 16 pounds per yard, and the radius of the sharpest curve 24 feet. The locomotives are designed to make the round trip of 9000 feet with six cars with one charge of air and to work on curves of 15 feet radius. The weight of the loaded cars is about 8500 pounds.

This is said to be the first of any kind of mechanical haulage anywhere for sole use in butt entries and rooms. The low cost of installation and operation and the greater adaptation to the conditions of the service and requirements cause the pneumatic system of haulage to be adopted in preference to electric haulage in many places.

At some of the larger bituminous mines in Pennsylvania the haulage is done entirely by electricity, sometimes the amount of coal hauled being something over 11,000 tons monthly. The system used is the same as the familiar "trolley" street railway—a single trolley and rail return. In the outside line, the wire is supported by wooden poles, and underground the insulators are carried on short wooden strips held to the roof by expansion bolts. The rails are of the 30-pound pattern, laid on 6-inch wooden ties or "sleepers," and are connected by wires to form a return for the electric current. The locomotive is a two-motor machine of about 33 horse-power. It is about 10 feet long, 5 feet wide, and its height allows its operation where the trolley wire is not less than 3 feet from the top of the rails. The gauge is 3 feet and the machine weighs about 6 tons. The wagons used in these mines weigh about 980 pounds, when empty, and hold about 2400 pounds of coal.

These locomotives have hauled "trips" of 19 of these wagons loaded, and 6 empty, up a 3 per cent. grade. The minimum curvature inside the mines is a radius of 51 feet. The records show a consumption of about 26 tons of coal per month, or about one ton daily for each working day, to generate the power.

The cost of haulage by this system is put at about two cents per ton.

CHAPTER XVI.

SHIPPING.

In drift mining, when the coal has been hauled "to daylight," the small mine wagons are drawn by the mules, or other power, to an elevated platform called a "tipple," and the contents are carefully weighed on a platform scales by the "weigh-boss,"—in America everybody is "boss:" "boss-driver," "mine-boss," "fire-boss," "stable-boss," etc.,—who is an employee of the operator and is paid monthly. He is assisted in this operation by an individual styled a check-weighman, who is chosen by the miners, and is in their employ, receiving for his compensation a commission of one cent a ton on all the coal mined and weighed over the scales. It is the business of the latter to see that the miners receive due credit for all the coal that they send out, and his presence in the scale-house—if he is an honest man—is a sufficient guarantee that the miners lose nothing by dishonest weighing. To facilitate the matter, each miner, or sometimes two or three miners, will "work a number," that is, a number—1, 2, 3, 4, etc.—is given them, and all the coal sent out by him or them is credited to a given number.

The number given to each miner is branded on small pieces of wood, or is stamped on small brass checks, like baggage checks. These they get at the scale-house every morning and take them into the mines. When a wagon is loaded, the miner sticks the numbered bit of wood into an iron staple placed on the side of the wagon, or hangs the brass check on a hook provided for the purpose. When the wagon reaches the scales the weigh-boss or check-weighman removes the bit of wood or brass, and credits the coal to the number he finds upon it. These numbered checks are then carefully piled in little heaps—the same numbers in each pile—for the inspection of the miner when he comes from his work. After the coal has been weighed the wagon is pushed to the "tipple" itself, and tipped over into the large railroad car which stands on the siding underneath the platform. The dumping of the contents of the wagon is easily done by means of a swinging-gate on the end, held in place by a catch; when this catch is raised the gate swings open, and allows the coal to fall into a chute and thence into the railroad car below.

This is the simplest form of loading and shipping, but is only possible where the mine is opened by means of a drift. For the other system of openings—the slope or shaft—much more effort is required to raise the wagons from the various mine levels, and for this purpose we must employ machinery and the steam-engine.

Before the invention of the steam-engine the hoisting of coal to the surface from lower levels was a subject engaging the attention of the best mechanical minds of the time, and their contrivances, crude as they now appear, were both ingenious and effective.

"The most ancient machine in my knowledge, now in use," says Mr. Curr (over a hundred years ago), "is that invented by Menzey; but there are few situations that afford the requisites necessary to that invention.

"A stream of water with a fall of about half the depth of the pit is necessary, if any business of consequence must be done. Its construction consists of two rope-wheels fixed upon one horizontal axis, which are so proportioned to the depths of the water-pit and coal-pit as to reach the separate depths of the pits by the same revolutions; and the power applied is a tub of water large enough to overbalance the weight to be drawn. The second is the common machine, greatly in use in the neighborhood of Newcastle-upon-Tyne, the construction of which is a water-wheel and a rope-wheel upon one horizontal axis; and the power is a stream of water sufficient to overbalance the weight to be drawn.

"The method of obtaining this stream of water in the neighborhood of Newcastle and Sunderland, where there are, I presume, no less than 30 or 40 in number, is a fire-engine placed by the side of the machine, which raises the water alternately to the top of the wheel; but in two collieries where I have adopted them, the scheme is more advantageous than those at Newcastle, being able to be without a fire-engine erected solely for that purpose; in the winter season when water is plentiful, and the engines are generally sufficiently employed with draining the collieries, we have the aid of adjoining brooks, which do our business; and in the summer season our engines are so constructed as to apply a part of their power to raise the water to the top of the wheel."

This is curious reading to the modern American coal operator; the idea of having a fire-engine—*i.e.,* of Savery, afterwards the steam-engine of Watts—to pump water on the wheel instead of using the engine-power direct; and reminds the writer of a similar suggestion, made to him some years ago, that in cases where windmills were used they could be made to revolve, in the absence of wind, by simply connecting a steam-engine to the power-wheel! In "Fossil Fuels" a contrivance for elevating coal by water is described as follows: "The vicinity of a pit nearly sunk for working, happening to include an old shaft heavily watered from near the top, an axle with drums was placed across; to one of these was suspended by a rope a large tub, and from the other a rope was carried over the head-wheels at the adjacent pit,—the tub being at the top of one pit while the corfe (basket of coals) was at the bottom of the other,—and *vice versa.*

"The tub, thus suspended near the spring, is made to stand constantly full of water; on the ringing of a bell from the pit, the common intimation that the corfe must be drawn up, a catch is let go by the banksman, who, pressing upon a brake to regulate the velocity of the machinery, suffers the tub to descend to the bottom, when a valve is opened and the water flows out, the corfe at the same moment being ready for loading at the other pit's mouth. An empty corfe being hung on, is just so much heavier than the empty tub that the former descends while the latter is brought up and secured in the situation first described."

The oldest form of lifting coal to the surface was by means of a "horse whim." This method was employed as far back as the middle ages. It consisted essentially of a wooden framework over the shaft, on which were fixed two wooden rollers or pulleys. From one of these rollers hung a rope, to the end of which was attached the *loaded* corfe or basket of coal; the rope passed over this roller and around an upright drum with three or four turns and thence over the other roller, and was attached to the *empty* corfe or basket. When the upright drum was made to revolve,—by means of an extended arm to which was hitched a horse,—the empty corfe was lowered and the loaded one was raised to the surface.

For very many years this was the only way known of lifting the coal, or in fact any other mineral or bulky material. The transportation of a wagon-load of coal for any number of feet horizontally was simply a question of making an even road-bed of wood or iron, when a comparatively small power was necessary to haul it the required distance, but when it came to lifting wagon and coal vertically, a much greater power was necessary, and the difficulties of construction increased.

Heretofore the loaded basket or bucket, ascending, swung at the end of a vibrating rope,—swaying back and forth in its passage up the circular well or shaft,—while the descending empty basket also hung loosely suspended at the other end of the rope, and frequently they came together in the middle of the shaft with fatal results. It was to prevent this that Mr. Curr, an Englishman, invented the cages, fitted at the sides with conductors, upon which the loaded wagons are wheeled and raised bodily with their contents to the surface, the empty wagon in its opposite cage descending simultaneously and without the possibility of a collision. An every-day example of this invention can be observed, in its highest state of perfection, if the reader will kindly "take the elevator," and ascend to the top floor of any of our lofty office buildings. To realize what has been done in this direction, he can then imagine his sensations should the luxurious cage with its mirrors and electric light be suddenly taken away, and he be obliged to descend to the ground floor in a bucket, loosely dangling from the rope end, and occasionally bumping against the sides of the shaft; add to this the fear of striking against the other bucket going up, and a fair idea can be gained—barring the additional terror of total darkness—of the dangers ever present in the old style of lifting coal and the miners from the mines to the surface.

But with the invention of cages and conductors came great improvements in the steam-engine, and to-day the great "winding-engines" raise the loaded wagons of coal with certainty and precision, the speed attained being greater by far than was ever dreamed of in those days by the boldest inventor. And in these engines the

English and French are still our superiors for one reason, if for no other: the greater depths of their shafts as compared with ours. I have given these comparisons in a previous chapter, and it is not necessary to repeat them here; it is sufficient cause for congratulation that such is the case.

The shipping of bituminous coal after it has reached the surface is a very simple affair, the wagon being merely tipped over on a rocking platform, as previously explained, into a chute, and thence into a railroad car. This operation having been completed, the car is loaded for the market with "run-of-mine" coal,—*i.e.*, all the coal that comes from the mine without any preparation. The semi-bituminous coals of Pennsylvania, Maryland, and Virginia, including the Clearfield, Cumberland, and Flat Top coals, are usually shipped this way. But it happens, and particularly with the bituminous or gas coals, that the customer requires a more clean and lumpy coal, in which case it is necessary to have it screened. This is done by putting into the bottom of the chute long iron bars, set an inch and a half apart, instead of the solid iron plates, making a screen 15 to 18 feet long. When the coal is dumped from the wagons directly on these bars, the fine coal falls through the openings, and the lumps pass down over the bars into an iron platform suspended from the scales, where it is weighed and then dumped into the railroad car beneath. A car loaded with this coal which passes over the bars is invoiced as "lump coal."

The coal which has dropped between these bars is caught on a second set of irons, which are placed only three-quarters of an inch apart, and in like manner some of the fine coal drops between these bars, and the lumps pass down over them. The coal passing over the bars is caught and weighed, and then dumped into the car below. This car would be dispatched as "nut coal," and the fine coal that passed through the screen is sold as "slack coal." The "lump" and "nut" coals mixed together are known to the trade as "three-quarters coal," which is the favorite size with consumers. In fixing the rate to be paid the miners for this kind of coal a price is made only on the coal that passes *over* the screens, and is therefore proportionately higher per ton than the rate paid for mining the semi-bituminous coals, where run-of-mine is shipped entirely. Revolving screens are used at some mines for screening out the slack.

The tracks underneath the tipples are arranged so that the railroad cars intended for the different kinds of coal can be loaded by "dropping them down" a slight grade into the proper position.

Where river transportation is available the tipples are made to facilitate the loading of the coal directly into the barges or boats, which are towed into position under the overhanging chute, and are then sent down the river, whole fleets of them at one time, in charge of large flat-bottomed steam tow-boats.

Anthracite coal upon being raised to the surface is prepared for the market with much more elaborateness than either the semi-bituminous or the gas coals. The householder, to whom a large proportion of this coal is consigned, demands that all slate, dirt, fine coal, and impurities shall be carefully removed before he will admit it to his cellar. This requires, on the part of the operator, a large outlay in the first cost of erecting a tipple,—in the anthracite region called a "breaker,"—frequently amounting to a hundred thousand dollars or even more, in which to properly prepare the coal. Here the coal, on arriving at the surface, is screened over bars, then hand-picked, crushed between rollers, run through separating cylindrical screens and chutes for another picking, and sometimes is even washed before it is ready for shipment.

To accomplish this the loaded mine wagons are hoisted to the top of a large frame structure,—sometimes one hundred and fifty feet in height,—where the coal is dumped, and finds its way over screens and chutes by gravity to the railroad cars beneath. In its devious way through inclined troughs from top to bottom the run-of-mine coal is separated by screening and crushing into the various domestic sizes. This is described by Mr. Chance as follows:

"When a mine car comes from the mine it goes directly to the dump, and the coal is dumped upon a set of inclined bars or into a chute or pocket, from which it is slowly fed under a gate and allowed to slide down over the bars. These bars are placed from three to six inches apart and separate the coal into two portions that are to be separately treated.

"That portion passing through the bars is usually conveyed directly to a large but short screen, known as a dirt or mud screen, which separates the fine coal ('pea' and smaller sizes), but it is sometimes hand-picked before passing to this screen.

"The 'broken' and 'egg' sizes coming from the mud screens are picked free from slate and sent direct to the pockets for shipment, or sent to the 'pony-rolls' or 'monkey-rolls' to be broken down into 'egg,' 'stove,' and 'nut' sizes.

"That portion passing over the main screen bars runs out upon the 'platform,' which is a flat or slightly inclined floor covered with iron plates, and is cleaned by the platform men. The slate and rock are picked out and sent down the rock chute, the good 'lump' coal goes to the lump chute, and the 'rough coal' to the 'crusher rolls' to be crushed and again screened and separated into domestic sizes."

Anthracite coal is thus crushed and screened into the following well-known trade sizes:

Lump, over bars about 7 inches apart. Steamboat, through bars about 7 inches apart and over bars about 5 inches apart. Broken, over a mesh $2\frac{5}{8}$ inches and through a mesh $3\frac{1}{2}$ inches. Egg, over a mesh 2 inches and through a mesh $2\frac{5}{8}$ inches. Stove, over a mesh $1\frac{1}{8}$ inches and through a mesh 2 inches. Nut, over a mesh $\frac{3}{4}$ inch and through a mesh $1\frac{1}{8}$ inches. Pea, over a mesh $\frac{1}{2}$ inch and through a mesh $\frac{3}{4}$ inch. Buckwheat, over a mesh $\frac{3}{16}$ inch and through a mesh $\frac{1}{2}$ inch.

The "sizing" is not uniform in the several districts, but the foregoing is sufficiently correct for trade purposes.

The cost of mining anthracite coal varies from $1.47 per ton to $2.51, as given by one of the largest operators during a period covering ten years. This does not include royalties,—from 20 to 40 cents per ton,—but these figures only approximate the truth, which is difficult to obtain.

PART III

TRANSPORTATION

CHAPTER XVII.

WATER TRANSPORTATION.

WITH the descriptions in preceding chapters, first of the origin and then the gradual development of American coals, it is now in order to illustrate the various methods of conveying the coals from the mines to the consumer. This matter of transportation long vexed the patient souls of our forefathers, and many men now living recall the arduous efforts made in the beginning of the coal trade in this country to provide the ways and means for its accomplishment.

In England, where the mines were close to the seaboard, the task was not so formidable; the same long-suffering women and girls, trained to the burdensome task from infancy, carried the coal on their backs, not only from the mines to the surface, but often some 200 or 300 yards farther, to the tipple, from whence it was discharged into the waiting vessels. Where the distance was too great to make women labor profitable, horses were substituted, carrying the coals in packs on their backs, and afterwards in carts. But England was an old and settled country when its coal development first assumed any magnitude; the distance from the mines to the seaboard was short and the roads well travelled. In our country the conditions of early transportation were reversed: the distances long, and the roads nothing but Indian paths through primeval forests. Transportation of coal on the backs of women, or men, was out of the question, and it was equally impossible to consider, in a commercial sense, the employment of horses or mules. I have instanced a case in 1812, when Colonel Shoemaker, of Pottsville, loaded nine wagons with coal and hauled it over the roads nearly a hundred miles to Philadelphia. The cost of this movement was about $28.00 per ton, as compared with the rail transportation today of $1.70: "with difficulty he sold two loads, and he gave the other seven loads away."

From these discouraging efforts towards bringing the coal to market by wagons, equally disastrous trials were made of the rivers traversing the States from west to east. But while the flow of water was sufficient during freshets and at certain periods of the year, the river-beds were shallow and full of rocks, so that the arks laden with coal performed occasional trips full of perilous adventure to all, and of wrecks so numerous that it was apparent some way must be devised less hazardous and expensive. Such a system was found in the numerous costly canals, which at this time were projected in various parts of the country. It was found that, even under the most favorable conditions, the descent of the river was as nothing when compared with the labor of returning up the stream. Dr. Eagle writes: "Many of the settlers on the head-waters of the Susquehanna River took their families and goods in canoes up that stream. Their canoes were generally managed by a steersman and a bowsman, who placed steel-pointed setting poles upon the bottom of the river, upon which they threw their whole weight and force, and thereby propelled their canoes forward, and by such continued efforts frequently made 25 miles a day against the current, carrying in canoes from three-fourths of a ton to one ton a trip. In case of low water in the streams, the boat-crew would be compelled to remove the gravel and fragments of rock from the line of their course and wade for miles at a time in the stream, carrying and dragging their boats forward."

The boats used for descending a stream only included the flat-boats, arks, and rafts. These were sold for lumber and broken up when they arrived at their destination. Improved crafts called keel-boats and barges were used for ascending or descending the stream. "The supplying of towns and cities on the Ohio and Mississippi

Rivers with Pittsburgh coal became an established business at about the close of the Revolutionary War. Down to 1850, all the coal shipped westward from Pittsburgh was floated down the Ohio River in large flat-bottomed boats with the spring and fall freshets, each boat holding about 15,000 bushels. The boats were usually lashed in pairs, and were sold and broken up when their destination was reached. In 1850 steam tug-boats were introduced." A writer describes: "In the early days of flat-boating, a safe return, even when the venture had not proved financially profitable, was a grand event and the occasion of tumultuous joy. The business had a special class who sought it for its adventure and dangers as much as for its profits. The river pirates met in the flat-boatmen of that early day a class ready, eager, and willing for the fray, a class which, like the ranchers of the plains, accounted a trip tame and spiritless if unattended with danger. They were rough and ready, soulless and care free. Dreamily floating down the Ohio, they whiled away with song and dance the lazy hours.

> "'Down the river, down the river,
> Down the O-hi-o-o!'

"The boatman's horn waked the echoes from distant hills, more musical than steamboat whistle or that ear-distracting horror, the calliope. It was a romantic life befitting the grand scenery and rude time. Ninety days on a slowly moving flat-boat, the scenery constantly changing, but ever wild and beautiful, was a thing never to be forgotten. The spice of danger in it only gave it zest; an occasional adventure with river sharks only relieved monotony and added interest.

"It is difficult for one looking on the Ohio River to realize that once flat-boats, broad beams, and the queerest craft that ever floated, did all the transportation business from the head-waters to New Orleans. A flat-boat, scarcely moving, with rude arrangements for cooking on deck, almost under water, with long oars attached to the sides, is a type of its time almost as grotesque and odd as the Viking ship recently dug up in Norway. Perhaps one day it will excite as much archæological wonder, for it already recalls a time we fail to understand,—a condition of society and of our country we can scarcely appreciate. The leisure-loving, deliberate, slow-moving flat-boat was fast enough for its day and people. There was luck in its leisure."

The coal shipped in arks down the Susquehanna River during the year 1827 amounted to about 11,000 tons. Says Mr. Ringwalt: "Almost every rock and projection along the Susquehanna, from

Marietta to Port Deposit, has a name familiar to the raftsmen. In many instances these points received their titles from the fact that rafts were once stove on them. Here are a few of the odd names: 'Spinning Wheel,' 'Sour Beer's Eddy,' 'Blue Rock,' 'Turkey Hill,' 'Brothers,' 'Old Cow,' 'Hangman's Rocks,' 'Horse Gap,' 'Ram's Horn,' 'Slow and Easy,' 'Hollow Rock,' 'Hog Hole,' 'Sisters,' and 'Old Port Bridge.'

"But the introduction of steam changed the whole condition of river traffic. Under its powerful impulse the rivers were rendered navigable upstream as well as down, and in 1811 the 'Enterprise,' a keel-boat made at Marietta, but fitted up at Pittsburgh with an engine and a stern wheel, under an arrangement with Robert Fulton, left Pittsburgh on its trial trip, and afterwards ran between New Orleans and Natchez until 1814, when it was wrecked. It was between 300 and 400 tons' burthen and cost $40,000."

Morris Birbeck, an English traveller, in a book printed in London in 1818, entitled "Letters from Illinois," expresses the opinion that "the upward navigation of these streams (the Ohio and Mississippi) is already coming under the control of steam, an invention which promises to be of incalculable importance to this new world."

At about the time of the Revolutionary War, when thirteen original States were struggling for independence, the question of the construction of canals in various States, notably in Pennsylvania, Maryland, and Virginia, was one uppermost in the minds of the leading men of affairs. Washington took a deep interest "to the creation of practicable connection between the waters of the Chesapeake and the Ohio. Largely through his instrumentality, a charter for the construction of such a work (the Chesapeake and Ohio Canal) was obtained from the States of Virginia and Maryland, and also valuable grants of land and money." This was the first important and extensive work designed to connect the Atlantic seaboard and the Western States on which a vigorous commencement was made, and Washington was the first president of the company formed to prosecute that undertaking. His attention had been called during the Revolutionary struggle to the importance of the natural advantages for securing a cheap through water route, which existed in New York, but he preferred to give close attention to the project which was designed to establish such an important channel through the regions with which he was most familiar and which he had personally explored during, previous to, and after his connection with the ill-fated Braddock expedition. Work was commenced in 1828, and in 1850 was completed for 180 miles of the line, leading from Cumberland to Georgetown.

From various authorities I have obtained the following interesting particulars of the tribulations of the Union Canal Company.

The Union Canal was the outgrowth of a scheme first agitated about 1760 for improving the navigation of the Schuylkill, which, after a small amount of work was done, was revived in 1771, and then made part of a project for uniting the waters of the Susquehanna and Schuylkill, officially reported to be feasible. Mainly on account of the disturbing influences arising from the Revolutionary War, this project was allowed to slumber until 1791, when it was decided that the proper plan would be to organize a company to do the work. The capital was fixed at 1000 shares at $400 each, and the title of the company was agreed to be the Schuylkill and Susquehanna Navigation Company. The Legislature passed the act of incorporation September 29, 1791. Books for subscription were shortly afterwards opened. Such was the interest and excitement that 40,000 shares were subscribed for, although there were but 1000 to be sold. In this dilemma the managers resorted to a lottery to determine who should be the successful bidders. The chances for the prize were one in forty, and the lucky holder of the drawn number had the privilege of buying the stock at par, whilst thirty-nine others just as anxious were excluded.

The persons interested in this project desired to have the work very complete. It was not enough that the commerce of the Susquehanna and the fruitful counties upon that river should be brought to the Schuylkill. The banks of the latter, in 1791, were as secluded and almost as wild as they had been a century previous. Trade was conducted on the Delaware, and in order to complete the scheme it was considered necessary that a canal should be built between the Delaware and Schuylkill, so that the produce coming down the latter from the west could be carried over and landed at the wharves of the merchants of Philadelphia. To accomplish this object, the Delaware and Schuylkill Canal Company was chartered by Act of April 10, 1792. Power was given to the company to take water from the Schuylkill anywhere between the mouth of Stony Creek, at Norristown, and the northern boundary of the city of Philadelphia. The capital was 2000 shares at $200 each. The stock was promptly taken, and the company organized by the election of Robert Morris, president; Timothy Matlack, secretary, and Tench Francis, treasurer. The work was commenced in November, 1792, near Norristown Mills, and prosecuted for some years.

With Robert Morris, the famous financier of the Revolution, at the head of these organizations, they commanded such an unusual degree of public confidence that they were regarded as the leading canal enterprises of the country. Unfortunately, they were overwhelmed with disaster. Either on account of errors in plans adopted, miscalculations of cost, failure to procure necessary means, financial convulsions, or a combination of these difficulties, they were compelled to suspend operations after an outlay of $440,000, which was an immense sum in those days. This suspension, and an interruption of active operations on the Chesapeake and Delaware Canal, which occurred a few years later, had a disastrous or discouraging effect on all similar projects for a considerable period.

On the 2d of April, 1811, the Legislature passed an act to incorporate "the Union Canal Company of Pennsylvania." The name was chosen because the new corporation was really a union of the old Schuylkill and Susquehanna and the Delaware and Schuylkill Canal Companies. The preamble recited that those corporations had made strenuous efforts to carry out the objects of their charters, but had failed. They were, therefore, dissolved, and a new company formed of the stockholders of the old corporations, whose relative rights were adjusted in the new distribution of the capital.

CHAPTER XVIII.

CANAL SHIPMENTS.

WORK on the Union Canal was again interrupted by the War of 1812, and comparatively little was done until a mode for raising funds to continue operations was furnished by the passage of an act March 29, 1819, granting an interest of six per cent. to subscribers to stock of the canal, with the understanding that the money needed for paying such interest should be derived from a lottery or series of lotteries authorized. To increase the feasibility of this scheme the company was granted a monopoly of the right of conducting lotteries in Pennsylvania. This programme was materially strengthened by the passage of an act on March 26, 1821, by which the State was pledged to pay any deficiency of interest which the lottery could not produce.

A power to issue lottery tickets had been part of the original scheme, granted by an act passed April 17, 1795, but up to 1810 the company had only realized about $60,000 from the lottery. Subsequently the lottery operations became quite lucrative, and a source of great abuses.

The plan of aiding the Union Canal by giving it exclusive authority during a considerable period to establish lotteries was by no means peculiar to Pennsylvania. It seems to have been a favorite resource with adjacent States for the nominal accomplishment of similar purposes. A lengthy address, issued in Philadelphia in 1833, setting forth the evils of the lottery system, said that there were more than two hundred lottery offices in that city, and that there had been offered for sale in them during the year tickets in 420 schemes, authorized by New York, Virginia, Connecticut, Rhode Island, Delaware, Maryland, and North Carolina. The sale of tickets in all these schemes, which represented aggregate prizes of $53,136,930, was prohibited by law in Pennsylvania, except twenty-six schemes for the benefit of the Union Canal, which represented prizes amounting to $5,313,056. In commenting upon these facts the address referred to said: "Thus the people of Pennsylvania have been made to contribute to the internal improvements of New York, Virginia, Connecticut, Rhode Island, and North Carolina, Maryland, and Delaware, as well as to pay a large sum to a company of their own State, whose grant has expired. . . . Pennsylvania, by being the great mart for nearly all the lotteries of the United States, has reason for emphatic complaint. In defiance of all her legislative prohibitions of foreign lotteries, her citizens are annually subsidized to an immense amount; perhaps for a church in Rhode Island, or a railroad through the Dismal Swamp, or for other improvements in which she has as remote a prospect of interest or advantage."

Partly on account of the increased success of lottery operations, and partly on account of the material aid derived from the substantial assurances furnished by the Act of 1821, the managers of the Union Canal were enabled to resume operations in that year, and in about six years from that time the work was finished, thirty-seven years after the commencement of construction, and *sixty-five years* after the first survey. The Union Canal was nearly eighty miles long, from Middletown, on the Susquehanna, to a point on the Schuylkill a short distance below Reading, and was adapted to the use of boats of 25 to 30 tons' burthen. At Middletown it was connected with the Pennsylvania Canal, leading, by various connections, to Pittsburgh and Erie, to Tioga in the north, and to the Bald Eagle, on the west branch of the Susquehanna. At Reading it was connected with the works of the Schuylkill Navigation Company, leading to Philadelphia. In 1828 the cost of the Union Canal was estimated at $1,600,000, and its small locks, and the probability that much of the business of the Susquehanna would be conducted over the projected Philadelphia and Columbia Railroad, were referred to in that year as causes likely to militate against its financial success, and these apprehensions proved to be well founded.

Of the other famous canals built there were the Delaware and Hudson and the Erie, in New York, and the Delaware and Raritan in New Jersey. In 1817 work was commenced on the canal of the Schuylkill Navigation Company, but it was not until 1825 that anthracite coal began to form the principal part of its tonnage.

Starting at Mauch Chunk, Pennsylvania, as the initial point, Mr. Taylor, in his "Statistics,"—that fountain-head from whence the writers on coal have drawn their inspiration for many years,—describes the "Stream of the Lehigh Coal Trade." "The main stream, *i.e.,* Lehigh Navigation, and the lateral channels—Morris Canal and Delaware and Raritan Canal—through which the anthracite finds its way to market. True it is, the stream has hitherto flowed somewhat irregularly; sometimes embarrassed by natural obstacles and unexpected calamities; sometimes interrupted by temporary causes, yet has it ever pursued its accelerated course, and onwards advanced in an accumulated volume. Notwithstanding every check, always has it surmounted all barriers;

always maintained its progressive character. Always has it given promise, in no distant time, of a mighty flood—prolific, fertilizing, reproductive. Success, then, to the stream of the Lehigh Coal Trade! onward may it flow, swelling in its volume; bearing on its surface and in its inmost depths the elements of prosperity to all who embark upon its waters! For ourselves, and in our day, we perceive but the beginning. We approach but the fountain-head—the margin of the stream to whose capacity we can suggest no ultimate limit. We see, but darkly, the outline of that magnificent future to which all things are tending, when its projectors shall cease to exist."

This prophetic vision was recorded about sixty years ago. The stream of anthracite, including every source and tributary, broadened at its mouth no wider than an annual capacity then of a paltry 2,000,000 tons. To-day the stream has widened to 50,000,000 tons, and even now "we can suggest no ultimate limit." The comparison is even more wonderful when we turn to bituminous. In 1845 a few thousand tons of this coal were floated from Tennessee down the river of the same name, 700 miles, to the Ohio, and thence by the Mississippi 1000 miles farther to New Orleans, making a voyage of no less than 1700 miles of inland navigation. From the western margin of the same coal-field a small quantity of coal was sent down the Cumberland River, nearly an equal distance, to its place of destination.

Sixty years ago the amount of bituminous coal mined in the two Virginias was about 400,000 tons, most of which was mined in Virginia.

At this time but little coal is mined in the older State, but West Virginia is forging ahead with rapidly increasing tonnage, and threatens to displace some of the Pennsylvania product. At present West Virginia produces 25,000,000 tons of coal annually. A writer called attention to this condition some time ago as follows:

"The reasonable certainty that the Monongahela River improvements will be purchased by the government is causing more or less anxiety among operators. The bill making the appropriation has already passed the House and is in committee in the Senate.

"It is thought by leading operators that free navigation on the Monongahela will be attended with a change of conditions which the coal producers should endeavor to anticipate to avoid a shock to the industry. The bill before Congress carries with it appropriations for the improvement of the head-waters of the stream, to make it navigable from Fairmount, West Virginia. It is thought when this is accomplished the cheaper coals of that State will come into active competition with the Pittsburgh article.

"The coals from the two States are substantially from the same vein, and are nearly equal in quality. The cost of coal lands is from $20.00 to $50.00 per acre in West Virginia, and from $200 to $300 an acre in the Monongahela Valley. It is maintained, also, that the veins in the Mountain State are from 4 to 10 feet thick. Labor is much cheaper, and owing to the thickness of the veins, it is claimed, will always be cheaper. It is stated, also, that the mining laws of West Virginia are less restrictive in requiring safeguards to miners, and in various other ways favor the operators in comparison with the Pennsylvanians.

"These matters are now engaging the attention of local operators, and an effort is being made to endeavor to estimate what results may be expected from this threatened competition in a very few years."

When West Virginia was mining 400,000 tons, Pennsylvania's bituminous tonnage was about the same amount. To-day the Keystone State is at the front with a bituminous output of 100,000,000 tons.

In 1838 the cost of transporting Cumberland coal from the mines to tide-water, Georgetown, by canal, was $2.85 per ton. The cost of mining was put at $1.00 per ton,—"the dollar of our daddies," however, with a great purchasing capacity. Maryland was then doing about 8000 tons annually, as "at that time the means of transportation were very limited and access to the mines was difficult." The production has increased to over 4,000,000 tons. In those "good old times" the price obtained for Cumberland coal f. o. b. in Baltimore was $6.00 per ton; and of Allegheny coal in Philadelphia, $7.00 per ton!—the same coals which are sold to-day by the dreadful monopolies and "coal barons" at $2.35 and $2.20 delivered. No wonder that Nova Scotia took advantage of her opportunities. We are informed that "the external trade coastwise in this coal is quite unimportant. Boston, in 1846, received but 175 tons from Philadelphia, and can purchase Nova Scotia coal on much lower terms."

In these early days of canal navigation, "The coals of the Lackawanna or Carbondale district are transported to New York by the Delaware and Hudson Canal, 108 miles; railroad, 18 miles, and river navigation, 91 miles. Total, 217 miles; amount, 388,000 tons. The coals of the Wyoming district descend the Susquehanna 194 miles to tide at Havre de Grace; in all about 68,000 tons."

Mr. Taylor estimates the total amount of bituminous coal mined in the year 1847 in the United

States at 1,750,000 tons. Our present day authority, Mr. Parker, in his annual report, gives the total amount of the same kind of coal produced in the United States in the year 1902 as 260,000,000 tons. Truly, a most remarkable growth of a single industry, and one that must astonish the most careless reader.

But this great increase was not accomplished by the dreamy raftsmen, listlessly floating down our inland rivers, or by the costly canals, which in their day served as the only means of transportation for the product of the mines to tide-water.

In that interval of fifty-five years was developed the puffing, hustling locomotive. And the musical blast of the boatman's horn was silenced by the triumphant shriek of the steam-whistle.

CHAPTER XIX.

RAIL SHIPMENTS.

It has taken a great many years of time and reams of literature and controversy to prove the superiority of rail transportation for coal over canals. Even now there are engineers of ability who question the movement of coal-cars over our trunk railroads, at express speed, and equipped with self-couplers, air-brake, and all the modern inventions, as one admitting of debate, to say the least.

In 1835 an able and exhaustive report upon the comparative cost of transportation on early canals and railroads was made to the New York Canal Commissioners by Messrs. John B. Jervis, Holmes Hutchinson, and Frederick W. Mills, civil engineers of large and varied experience.

These gentlemen reported that the cost of transportation on railroads then was $3\frac{1}{2}$ cents per ton per mile on a level road, and that this cost would be increased upon different ascending grades in the following ratio:

	Cents.
Ascent of 10 feet per mile..............	4.20
Ascent of 20 feet per mile..............	4.90
Ascent of 30 feet per mile..............	5.95
Ascent of 40 feet per mile..............	7.28
Ascent of 50 feet per mile..............	8.19
Ascent of 60 feet per mile..............	9.66
Ascent of 70 feet per mile..............	11.41

They also reported that the cost of transportation, exclusive of tolls, for a ton of 2240 pounds on the Erie Canal, would be 1.04 cents per ton per mile; and that if the canals were reduced to a level, the cost would be only $\frac{828}{1000}$ of a cent per ton per mile.

Also: "Taking the facts we have obtained as a basis, we find the relative cost of conveyance is as 4.375 to 1, a little over four and one-third to one, in favor of canals; this is exclusive of tolls and profits."

Also: "The average tolls on the Erie Canal are less than one cent per ton per mile; assuming an average toll of one cent per ton per mile, the ratio of the entire cost of transportation and tolls is (2.5 to 1) two and a half to one in favor of canals."

The report closes as follows:

" We are, therefore, led to the conclusion that in regard to the cost of construction and maintenance, and also in reference to the expense of conveyance at moderate velocities, canals are clearly the most advantageous means of communication. On the other hand, where high velocities are required, as for the conveyance of passengers, and under some circumstances of competition for light goods of great value in proportion to their weight, the preference would be given to a railroad.

"It may be observed in favor of railroads that they admit of advantageous use in districts where canals, for want of water, would be impracticable. This advantage often occurs in mining districts, and sometimes for general trade, where it is necessary to cross dividing ridges at a level too high to obtain water for their summits.

"The facts and reasonings presented, we believe, clearly show that both canals and railroads are highly important means of internal communication; that each has its peculiar advantages, and will predominate according to the character of the route and the trade for which it is intended to provide."

It was upon this basis, and by reason of these and other similar representations, that the work of enlargement of the Erie Canal was commenced in 1835 and ultimately prosecuted to completion in 1862.

The Baltimore and Ohio Railway, in 1827, was incorporated and designed as a rival of the Chesapeake and Ohio Canal from the beginning. In *Railway Progress* Mr. Ringwalt says: "They both became urgent applicants for State aid from Maryland, and an animated struggle was prosecuted between those corporations, which embraced lengthy discussions of the merits of the relative methods. A strong point in favor of railways, which was probably of sufficient importance to determine doubtful contests in their favor, was the success of the first two English lines used for general traffic, the Stockton and Darlington, opened in 1825, and the Liverpool and Manchester, opened in 1829."

For many years previously the English colliery proprietors had operated railroads in the transportation of coals from their mines; our old friend "Master Beaumont, in 1630, laid down wooden rails from his coal-pits, near Newcastle, to the river side," but it was 100 years afterwards when the first iron rails were laid at Whitehaven, and nearly 80 years more when "Blenkinsop's engine worked at Leeds, drawing 33 coal-wagons at the rate of 3¾ miles per hour." This was in 1812. In 1825 the Pennsylvania Society for the Promotion of Internal Improvements in the Commonwealth sent William Strickland to Europe to investigate what progress had been made "in the construction of canals, roads, railways, bridges, steam-engines, and various industrial arts." His instructions contained the following extract:

"Locomotive machinery will command your attention and inquiry. *This is entirely unknown in the United States,* and we authorize you to procure a model of the most approved locomotive machine at the expense of the society."

About this time short lines of railway were constructed in our country as feeders to the various canals. Of the first railway in the Schuylkill anthracite regions of Pennsylvania Daddow says: "It was not until 1827 that rails were used in the (Schuylkill) mines, and up to 1829 the coal was carted over common mud roads from the mines to the canal. Abraham Pott, of Port Carbon, was the first to build a model railroad in the Schuylkill region. It led from his mines to the canal, a distance of half a mile. Soon after the Mill Creek Railroad was built from Port Carbon to the Broad Mountain, about the present town of St. Clair. The distance is about three miles. The cost was $3000. This was in 1829."

An historical sketch of Pottsville states that in 1825 the Schuylkill Canal was opened to Mount Carbon, then a suburb of Pottsville, and in 1826 Abraham Pott built a railroad extending half a mile in length near Pottsville. The railway was made of wooden rails, laid on wooden sills, and was successfully operated in carrying coal, which, previous to that time, was hauled in wagons to the canal, and thence sent to market. In 1829 the directors of the Schuylkill Canal came to Pottsville and viewed this primitive road in operation. They were taken by surprise when they saw 13 railroad cars loaded with 1½ tons each, and they were shocked when Mr. Pott, the projector of this corduroy railroad, told them that in less than ten years a railroad would be in operation along the line of their canal. After-events proved that he was right in everything except as to time, for it was not until 1842 that the first train passed over the extension of the Philadelphia and Reading Railroad from Mount Carbon.

It is not within the scope of this story to give a history of railroads in America, but the following account of the first locomotive service cannot properly be omitted: "In 1828, John B. Jervis, chief engineer of the Delaware and Hudson Canal, sent his assistant, Horatio Allen, to England to investigate the application of steam to land transportation. Allen became convinced that Stephenson's ideas were destined to revolutionize commerce, and he therefore bought for the canal company three engines to be used on the initial railway in the United States. In May, 1829, the first of the engines was landed here, was put together by Allen, and exhibited at the foundry for several weeks. It was queer-looking enough, having four wheels connected by side rods. Vertical cylinders on each side of the rear end of the boiler communicated motion to a vast walking-beam, attached to the side rods of the driving-wheels by other long iron rods. The engine was, indeed, so covered with rods and joints that it resembled a large grasshopper. Having been delivered at Honesdale in good season, on the 9th of August, 1829, Allen had it put on the track, consisting of hemlock stringers or rails, in sections 6 by 12 inches, on which bars of rolled iron, 2½ inches wide and 1½ inches thick, were spiked. The hemlock rails were supported by caps of timber ten feet from centre to centre. The engine weighed seven instead of three tons, as had been agreed upon. The rails had been warped, and as the road crossed the Lackawaxen River, after a sharp curve, on a slender hemlock trestle, which, it was believed, would not support the engine, Allen was besought not to imperil his life on it. He knew there was danger, but, ambitious to connect his name with the first locomotive in America, he determined to take the risk. He ran the engine up and down along the coal dock for a few minutes, and then invited some one of the large assembly to accompany him. Nobody accepted, and, pulling the throttle-valve open, he said good-by to the crowd, and dashed away from the village around the abrupt curve, and over the trembling trestle, amid deafening cheers, at the rate of ten miles an hour. The Stourbridge Lion, as the engine was named, was attached, after the trial, to trains of coal-cars, and drew them satisfactorily on the docks; but it could not be employed to advantage on so slight a railway, which could not be fitted to the engine on account of the expense required. The Lion was, therefore, placed in a shanty on the docks, and stayed there for years. Finally it was taken to pieces, its boiler being carried to Carbondale and put in a foundry, where it is still in use. The other two engines shared the same fate."

In 1830 forty miles of railroad were constructed in the United States. Ten years later there was a total of about 2500 miles. To-day the whole country is intersected with a net-work of railroads aggregating over 203,000 miles, or six times the mileage of any other country in the world.

These railroads furnish transportation for the greater part of all the coal interest in this country, and a few principal roads carry all the coal from the mines to the Atlantic seaboard.

At the head of anthracite coal-carriers is the old Philadelphia and Reading Railroad, a corporation whose eventful history demands its own historian. "Originally projected for its present purpose,—an outlet or avenue to market for the Schuylkill coal region,—its first charter extended only to the city of Reading, 59 miles from its terminus on the Delaware River, near Philadelphia, as the right of constructing a railroad between Reading and Port Clinton, 20 miles, had already been granted another corporation, the Little Schuylkill Railroad Company, extending from Tamaqua to Port Clinton, 20 miles. From insufficient means, this company was unable to extend its road, and yielded its right and charter to the Reading Railroad Company, who, with a further extension of its charter beyond Port Clinton to Pottsville, went into an active prosecution of the whole work from Pottsville to the Delaware, 94 miles, under one charter, now known as the Reading Railroad."

On the 1st day of January, 1842, the first locomotive and train passed over the whole line between Pottsville and Philadelphia. A writer describes it as follows: "The event was celebrated with military display, and an immense procession of 75 passenger cars, 1225 feet in length, containing 2150 persons, 3 bands of music, banners, etc., all drawn by a single engine! In the rear was a train of 52 burden-cars, loaded with 180 tons of coal, part of which was mined the same morning, 412 feet below water-level."

The whole was under the charge of Moncure Robinson, chief engineer, and G. A. Nicolls, general superintendent. The entire capital invested up to this time was a little over $16,000,000.

Of the early efforts to improve the locomotive the Reading Railroad was then a favorite field for competitive effort, and some of the most notable achievements occurred on its lines. A statement of its superintendent, Mr. G. A. Nicolls, dated July 31, 1839, said of a Baldwin locomotive that it had been in use 15 months; that its performance was in every way satisfactory, and that it "drew at one time 45 cars, loaded with 150 tons of rails and iron, making in all 221 tons gross behind the tender, from Reading to Norristown, 41 miles, in 3 hours and 41 minutes, running time." This engine was presumably built in the early part of 1838.

On the Little Schuylkill Railroad the cars used carried 3 tons of coal. The wheels were 3 feet in diameter, and two of them on one side were loose on the axle, which also revolved. This arrangement was adopted to lessen friction on curves. Stage-coach bodies were used for the conveyance of passengers. These were succeeded by the little four-wheel cars known as "Jimmies," and later by eight-wheel cars.

For the transportation of coal no better located railroad exists in the world to-day. For the entire distance from the mines to the Delaware River the grades all descend or are level—in the direction of the loaded cars.

At Philadelphia is the eastern terminus of the railroad. Here are 23 wharves, extending from 300 to 800 feet into the Delaware River, with trestlework and chutes allowing a discharge of coal from the cars directly into the vessels. More than 60 miles of track are distributed on the wharves and the immediate neighborhood. Other shipping termini are Port Reading, New York Harbor, and Port Liberty, New Jersey.

In 1902 the Reading Railroad Company owned 900 freight and coal locomotives and 30,000 eight-wheel coal-cars. In addition to its equipment for land transportation, it also owned 487 barges, 21 steamers, and 15 steam-tugs for movements by water.

CHAPTER XX.

SEABOARD ANTHRACITE COALS.

The Pennsylvania Railroad, extending across the Keystone State and through the heart of the Alleghenies, the pride of every citizen of the commonwealth, stands, to every technical man and to the unprejudiced observer, for everything that is best in the progress of rail transportation. Beginning with its full share of the trials and tribulations attending the construction of the early American railways, this immense property to-day employs over 70,000 cars for the movement of its coal and coke trade, of which number 13,000 are used for the conveyance of anthracite.

Early in the fifties the State of Pennsylvania owned about 750 miles of canals and 120 miles of railroad. To construct these "improvements" the Commonwealth incurred a debt of over $50,000,000, some writers placing the sum at $100,000,000, in various appropriations made by the Legislature, the bulk of which was uselessly frittered away on "branch" railroads, while the host of political sharks feasted on the pickings. Embarrassed by debt and finding the "improvements" an unprofitable burden, "the State was finally induced to transfer them, to insure their completion, to incorporated companies, reserving to itself the right of controlling to some extent their policy and management."

Under this arrangement, the Pennsylvania Railroad Company acquired the "old State road," running from Philadelphia to Columbia. It also leased the Harrisburg and Lancaster Railroad, intersecting the old Columbia Railroad at Lancaster, and with its own "main line" from Harrisburg to Pittsburgh formed a through line aross the State from the Delaware River to the Ohio, a distance of about 350 miles.

In 1852 an observer wrote as follows: "The length of the Pennsylvania Railroad—*i.e.,* between Harrisburg and Pittsburgh—is 248 miles, of which about 212 miles are now in successful operation, while the whole of the remaining portion is under contract and rapidly advancing towards completion. . . . Calculations of the amount of transportation and travel that will pass over this great highway appear to be superfluous; . . . its business will only be limited by the capacity of a first-class double-track railroad," a prophecy which the present generation have seen fulfilled. In forty years the "Pennsylvania System" has grown to an operation embracing about 13,000 miles of main line railroad, and running across and into thirteen States of the Union.

During the year 1895 the aggregate coal and coke shipments over the Pennsylvania Railroad Division—*i.e.*, the lines between Philadelphia and Pittsburgh—amounted to 26,800,000 tons, or about 57 per cent. of its total tonnage.

I cannot better close this sketch of the greatest of rail transportation systems than to take the reader back just seventy years, and quote a few extracts from the pen of Peregrine Prolix, who wrote of his trip by rail, canal, and stage from Philadelphia to Pittsburgh at that time as follows:

"Two cars filled with passengers and covered with baggage are drawn by four fine horses, for about four miles to the foot of the inclined plane, which is on the western bank of the Schuylkill (in Philadelphia), and is approached by a spacious viaduct extending across the river, built of strong timber and covered with a roof. The cars moved at the rate of six miles an hour. . . . At the foot of the inclined plane the horses were loosed from the cars, several of which were tied to an endless rope, moved by a steam-engine placed on the top of the plane, and presently began to mount the acclivity with the speed of five miles an hour. . . . When the cars had all arrived at the top of the plane, some twelve or fourteen were strung together like beads and fastened to the latter end of a locomotive, which was already wheezing, puffing, and smoking, as if anxious to be off. All these little ceremonies consumed much time, and the train did not leave the top of the inclined plane until ten o'clock. . . . After many stoppings to let out passengers and let in water, and after taking into our eyes many enchanting views and little pestilent triangular cinders, we arrived at Lancaster at three P.M. without accident or adventure. . . . The roofs (of the viaducts) are so low as to prevent the locomotives from having chimneys of a sufficient height to keep the cinders out of the eyes of the passengers and to prevent the sparks from setting fire to the cars and baggage. The chimneys are jointed, and in passing a viaduct the upper part is turned down, which allows the smoke to rush out at so small a height as to envelop the whole train in a dense and noisome cloud of smoke and cinders. . . . We left Lancaster at five A.M. in a railroad car drawn by two horses tandem; arrived at Columbia in an hour and a half. . . . Here is the western termination of the railroad, and goods from the seaboard, intended for the great West, are here transshipped into canal-boats. . . . At four P.M. we went on board the canal-boat of the Pioneer Line to ascend the canal, which follows the eastern bank of the Susquehanna. . . . This machine is dragged through the water at the rate of three miles and a half per hour by three horses driven tandem. . . . The horses are changed once in about three hours. . . . The packet glided into the basin at Hollidaysburg. In this artificial basin, which is large and commodious, terminates that part of the Pennsylvania Canal which lies east of the Allegheny Mountains. The goods destined to the West are taken from the boats and placed in burthen cars, which are to carry them over the mountains by means of the Allegheny Portage Railroad, which commences here and leads by a gently rising grade, four miles from the foot of the mountain, whither the cars are drawn by horses. . . . Arriving at the foot of the plane, the horses were unhitched and the cars fastened to the rope, which passes up the middle of one track and down the middle of the other."

When the cars had reached the top of the first plane they were drawn on the "levels" by horses or engines to the foot of the second plane, and so on, until the traveller reached the top of the mountain, 2397 feet above ocean level, 1399 feet above Hollidaysburg, and 1172 feet above Johnstown, the eastern end of the trans-Alleghenian canal and the western terminus of the Portage Railroad.

Here the traveller again took the canal and, by packet, finally reached Pittsburgh.

Such were the journeys made by our fathers, and such were the first crude efforts made in transportation in the great State of Pennsylvania.

The thousands and millions of dollars expended in these costly works of canals and inclined planes have not been spent in vain. Such expenditure was justifiable and necessary to achieve the wonderful perfection in transportation which the Pennsylvanians are now enjoying. In 1904 the great Keystone State included within its borders 10,000 miles of railway, and the transportation of coal from its productive mines to the seaboard no longer presents any difficulties. In winter or summer, during high water or low, down stream or up, the constant movement of loaded coal-cars passes backward and forward to every city and hamlet, bringing power to the busy manufacturer and warmth and comfort to every hearth-stone in the State.

In 1847 the Delaware, Lehigh, Schuylkill and Susquehanna Railroad Company was chartered. The broad scope of its title came from the four rivers in Pennsylvania of the same name, and its proprietors planned well, for it is now the well-known Lehigh Valley Railroad, and has grown by extensions and leases to a system covering over a thousand miles of track, and an anthracite coal tonnage of over 7,000,000 tons annually.

To carry this from the mines to the customer requires 13,600 eight-wheel and 20,000 four-wheel coal-cars. This company owns the Lehigh Valley Coal Company, a concern organized in 1881 to mine and sell coal. Besides valuable anthracite lands, this company owns the Snow Shoe property in Centre County, Pennsylvania, embracing over 45,000 acres of bituminous coal.

The third of the anthracite railroads in tonnage is the Delaware, Lackawanna and Western.

"This company, having a charter antedating the present constitution of the State of Pennsylvania, is one of the few privileged to carry on coal mining and selling, together with transportation."

This was originally the Ligett's Gap Railroad, incorporated by special act of the Pennsylvania Legislature, approved April 7, 1832, chartered March 19, 1849; name changed by special act of Pennsylvania Legislature, approved April 14, 1851, to Lackawanna and Western; consolidated April 30, 1853, with the Delaware and Cobb's Gap Railroad (chartered December 4, 1850), and name changed to "The Delaware, Lackawanna and Western Railroad Company." The road was opened from Scranton to Great Bend October 20, 1851, and from Scranton to the Delaware River

May 27, 1856. In 1868 it acquired control of the Morris and Essex Railroad, which now, with the Warren Railroad, forms this company's line to the Hudson.

In October, 1882, a lease was made of the New York, Lackawanna and Western Railroad, which extended the line to Buffalo, making the total mileage now operated 898 miles.

The company's coal lands are in Lackawanna and Luzerne Counties, Pennsylvania, with a tonnage in 1904 of about 6,000,000 tons of anthracite coal, somewhat over 13 per cent. of the total anthracite production of Pennsylvania.

Following the Delaware, Lackawanna and Western Railroad in importance as an anthracite transporting company is the Central Railroad of New Jersey and its leased lines, the Lehigh and Susquehanna Railroad and Lehigh Canal. This latter-named railroad is credited with the transportation of over 5,000,000 tons annually of anthracite coal, and is owned by that old pioneer in the coal development of this country, the Lehigh Coal and Navigation Company, which first began business in 1820 by sending forward the first shipment of anthracite coal ever made in the United States,—that memorable 365 tons, one for each day of the year,—and has continued in business ever since.

It now requires 17,000 coal-cars to carry the tonnage of the Central Railroad of New Jersey, and its system embraces about 700 miles of railroad in the States of New Jersey and Pennsylvania.

The next in anthracite tonnage, the Delaware and Hudson Canal Company, is, of the anthracite coal-carriers, one of the most important systems of transportation in this country. This company was chartered in 1823, ten years before the "Reading." The account of the first locomotive run upon its railway, as given in a preceding chapter, marks the decline of the canal and the supremacy of the railroad. The canal at present forms a very small part of its transportation facilities. The first mining operations of this company were in the vicinity of Carbondale. A gravity road was built to carry the coal over the mountains to Honesdale; it was finished in 1829, and in that year the company carried 7000 tons.

In 1904 the Delaware and Hudson Canal Company transported over 4,000,000 tons of coal, all of which was the production of its own mines. In addition to this about 2,000,000 tons passed over its lines. The total length of railroad belonging to this company is 688 miles, and of canal 108 miles,—from Honesdale, Pennsylvania, to Rondout, on the Hudson River, New York.

To the coal operators in the north of England is unquestionably due the invention of the railroad, and the owners of the vast mileage we have to-day must acknowledge their indebtedness for its origin to the unscientific and illiterate colliers who contrived "the double parallel line of rails fixed to the ground and furnished with flanges to prevent the wheels of the wagons from slipping aside." The Romans may have repaired and strengthened the ruts made in their roads by putting blocks of stone in the wheel tracks, but that was not a railroad in the most liberal sense of the word, and to the coal men belongs the right of invention. These early railroads, known as "tramways," are in use to-day at many mines in England and America, and are indisputably the origin of all the rail transportation systems in the world.

To the same uneducated coal-worker belongs the honor, if any there be, of establishing the gauge, or distance between the rails, which occupied the attention of technical men to such an extent that the subject assumed the importance of national legislation and an interminable discussion called "the battle of the gauges."

When tramways were first used for transporting coal their gauge was naturally made to suit the ordinary road wagons which were to run upon them. This happened to be 4 feet 8½ inches, and after the "battle" which was waged between the most eminent engineers of the day, that gauge was fixed by a statute or act in 1846, and applied to "all railways in England and Scotland."

In America the contention was no less severe, and the earlier railroads were built of different gauges, according to the individual judgment then prevailing.

Under this unfortunate difference of opinion the old New York and Erie Railroad was chartered in 1832, and construction commenced in 1836 for a railroad of six-feet gauge.

The first annual report of the New York and Erie Railroad, dated September 29, 1835, after discussing the grades then proposed for that projected line, and the improvements which had been made in locomotives, and referring to elaborate investigations by distinguished engineers, says: "The board of directors now have the gratification of announcing to the stockholders the following result, to wit: That loads of sixty tons gross (or, deducting the weight of the cars, forty tons net) may be drawn in a single train from the Hudson River to Lake Erie, and at an average speed of from twelve to fourteen miles to the hour; that with the rate of speed augmented one-half, a locomotive engine will nevertheless suffice to transport two hundred passengers and their baggage; that no stationary engine will be requisite to any part of the work, and that one, or at most two, auxiliary engines (or pushers) will be requisite on the whole length of the line."

The credit of the State of New York was loaned to this company to the extent of $3,000,000, and afterwards, in 1845, the State released the property of its mortgage, "provided the company should complete the road to Lake Erie in six years, and the old stockholders surrendered one-half their stock." The amount necessary to complete the road was estimated at $7,000,000. Construction was resumed, and the road opened to Port Jervis and Binghamton in 1848, to Elmira in 1849, to Hornellsville in 1850, and to Dunkirk in 1851. In 1861 the road was reorganized under the name of the Erie Railway Company, and in 1878 a third rail was laid giving the standard gauge from Jersey City to Buffalo, and the company again reorganized under the name of New York, Lake Erie and Western Railroad Company. In 1881 it purchased the stock of the Blossburg Coal Company and a tract of 30,000 acres of coal lands in the State of Pennsylvania for $2,000,000. It also owns the Hillside Coal and Iron Company, the Northwestern Mining and Exchange Company, and the Towanda Coal Company.

In 1904 the coal and coke tonnage of the road amounted to about 9,000,000 tons, representing nearly 60 per cent. of its total tonnage. In 1895 the company was reorganized under the name of the Erie Railroad. Among the anthracite coal producers the "Erie" stands for 8 per cent. of the total tonnage, and has grown to a system covering over 2000 miles of track. For the movement of its coal traffic the "Erie" owns and leases about 17,000 coal-cars.

CHAPTER XXI.

SEABOARD BITUMINOUS COALS.

Among the recent railroads built almost exclusively for the transportation of anthracite coal, the Delaware, Susquehanna and Schuylkill Railroad, with its main line from Drifton to Gowen, adds nearly 2,000,000 tons of anthracite coal annually to the production, and the New York, Susquehanna and Western 1,500,000 tons of anthracite, under the trade name of "Jermyn."

This latter railroad is a consolidation of the New York, Susquehanna and Western Railroad and Hudson River Railroad and Terminal Company, made in 1893. In 1882 only 35,000 tons of this coal reached tide-water, and the remarkable increase in tonnage to 1,500,000 was accomplished in the few intervening years.

The New York, Ontario and Western Railway was organized in 1879 as successor to the New York and Oswego Midland Railroad. It ships anthracite over its own docks at Oswego on Lake Ontario, Cornwall on the Hudson River, and Weehawken in New York Harbor, drawing its supply from the heart of the Pennsylvania anthracite region near Carbondale and Scranton. Its annual anthracite production is 1,500,000 tons, with a trackage of about 500 miles.

The foregoing railroads constitute the main avenues for the transportation of anthracite coal from the mines to the Atlantic seaboard.

Ninety-five per cent. of all the anthracite coal lands in the United States is owned or controlled by these great transporting companies operating in the State of Pennsylvania. The remaining 5 per cent. is still held by private individuals, principally in undeveloped land. It has been estimated that about 5,000,000,000 tons of anthracite coal still remain unmined, which, at the present rate of production, will last just one hundred years.

In the bituminous fields the case is different. The lands are owned almost entirely by individuals, the railroads having little interest in or control over them. It is impossible to estimate the amount of coal unmined in the bituminous fields of America; any figures given would be the merest guesswork. It is apparently inexhaustible.

The principal bituminous carriers are the Pennsylvania Railroad, which is the largest transporter of coal in the United States, of which I have given an account in a preceding chapter,—in 1902 this railroad transported nearly 38,000,000 tons of coal and coke,—and the Baltimore and Ohio Railroad, stretching from Baltimore on Chesapeake Bay westward to the Missouri River, and to the Great Lakes in the north, passing through the centre of the great Appalachian coal range in the Cumberland region, where the bituminous coal-seams are the best and thickest. This was really the first railroad, as we now understand the term, ever built in this country. It was commenced in 1828, and two years later, in 1830, the first division, from Baltimore to Ellicott's Mills, was opened for travel. It was uncertain whether to use horses or steam as a motive power, but the report of Mr. Horatio Allen, who had visited England in the interests of the South Carolina Railroad Company, was the principal argument in favor of steam. In it Mr. Allen said, "In the future there is no reason to expect any material improvement in the breed of horses, while, in my judgment, the man is not living who knows what the breed of locomotives is to place at command."

In 1831 the Baltimore and Ohio Railroad Company offered a premium of $4000 "for the most approved engine which shall be delivered for trial upon the road on or before the first of June, 1831; and $3500 for the engine which shall be adjudged the next best." The requirements were as follows:

"The engine when in operation must not exceed

3½ tons' weight, and must, on a level road, be capable of drawing day by day 15 tons, inclusive of the weight of wagons, 15 miles per hour."

The engine which was produced in answer to these requirements was named the "York," and was built by Davis & Gartner, at York, Pennsylvania. This was of the "grasshopper" pattern, a few descendants of which could be seen in recent years in the yards of the Baltimore and Ohio Railroad at Canton in Baltimore.

When Mr. Forney wrote the chapter on American locomotives and cars in the "American Railway," he unearthed an old school history of Peter Parley's, written probably about 1830–35. In his chapter on Maryland he says:

"But the most curious thing at Baltimore is the railroad. I must tell you that there is a great trade between Baltimore and the States west of the Allegheny Mountains. The Western people buy a great many goods at Baltimore, and send in return a great deal of Western produce. There is, therefore, a vast deal of travelling back and forth, and hundreds of teams are constantly occupied in transporting goods and produce to and from market.

"Now, in order to carry on all this business more readily, the people are building what is called a railroad. This consists of iron bars laid along the ground and made fast, so that carriages with small wheels may run along on them with facility. In this way one horse will be able to draw as much as ten horses on a common road. A part of this road is already done, and if you choose to take a ride upon it you can do so. You will mount a car something like a stage, and then you will be drawn along by two horses at the rate of twelve miles an hour."

In 1832 the Baltimore and Ohio Railroad extended from Baltimore to Point of Rocks, on the Potomac River, 69 miles.

A report of a committee of the New York Legislature in 1832 said: "The most approved method of constructing railways is on the plan adopted by the Baltimore and Ohio Railroad Company. A line of road is first graded, free from short curves, and as nearly level as possible. A small trench is then formed for each track, which is filled with rubble stone, on which are laid blocks of granite or other suitable stone (in the place of wood), which will square about one foot, and of as great length as can be obtained. The upper end and inner surfaces of each track are dressed perfectly even, as well as the ends of the blocks at their joinings. Bars, or plates of wrought iron, near an inch in thickness, are then laid upon these blocks or rails, in a line with the inner surfaces, and fastened to the stone with iron bolts or rivets, entering about four inches in holes fitted to receive them, and at a distance of about eighteen inches. The distance between the two tracks, for the wheels, should be about five feet."

As on most other important roads, various modes of construction were adopted on the Baltimore and Ohio. In addition to the granite-sill method, six miles of single track were composed of stone blocks and wooden string-pieces, and a considerable part of the line rested on wooden sleepers (or ties). Of the first passenger car on the Baltimore and Ohio Railroad a modern writer says that on this road "ran, first of all, a little clap-boarded cabin on wheels, for all the world like one of those North Carolina mountain huts, with the driver perched on top of the front portico,—driver, because the motive power then was one horse in a tread-mill box."

Of cars used in early operations on the Baltimore and Ohio, Mr. George W. Smith, in his notes on "Wood's Treatise on Railroads," published in 1832, says: "The wheels of the wagons are made in accordance with the old-fashioned plan formerly pursued on some of the colliery railroads in Great Britain,—the felloe being slightly conical, and curving towards the flange: this has, however, been claimed as a new and important invention. The novelty of railroads in this country has induced many ingenious persons, connected with this railroad, to submit to the public, through the press, a number of devices purporting to be original, all of which (so far as they have been examined by the writer) are either in use or have been proposed elsewhere, with two exceptions,—namely, the mode of oiling the friction-wheel of the wagon, claimed by Winans, and the plan of oiling common axles by means of a cork floating in oil: the latter was introduced by Colonel Long."

Other accounts of early operations at Baltimore states that in December, 1828, Ross Winans exhibited in that city the model of a car weighing about 125 pounds and running upon tracks. It was repeatedly loaded with deposits of five hundredweight and two men, and the whole weight drawn by a piece of twine. This feat attracted much attention, as it was regarded as a remarkable demonstration of advantages that could be derived from the use of such anti-friction cars.

From such interesting early beginnings we note the present total length of all lines of the Baltimore and Ohio system, 2094.65 miles, constituting one of the most important highways for the transport of coal to nearly every important point in the United States east of the Missouri River. In

1902 the Baltimore and Ohio Railroad transported over 20,000,000 tons of coal and coke.

In 1902 the Norfolk and Western Railroad carried nearly 8,000,000 tons of bituminous coal and coke from the mines to the consumer. This large tonnage places the road among the larger bituminous transporting railroads within a brief period of time.

Prior to 1881 this railroad was known as the Atlantic, Mississippi and Ohio. The New River Railroad Company, the New River Railroad Company of West Virginia, and the East River Railroad Company of West Virginia, chartered to build extensions and branches of the Norfolk and Western, were consolidated with it on May 9, 1882. In 1890 the Scioto Valley and New England Railroad and the Shenandoah Valley Railroad were purchased. In 1892 the Ohio extension was completed and opened for traffic, and a lease made of the Lynchburg and Durham and the Roanoke and Southern Railroads. In 1893 the company leased the Columbus Connecting and Terminal Railroad, and completed its system of about 1500 miles.

The coal tributary to this railroad has become famous to steam raisers in nearly every corner of the globe under the trade name of "Pocahontas," and comes from the States of Virginia and West

Virginia over the Norfolk and Western Railroad to tide-water at Norfolk.

From the same territory the Chesapeake and Ohio Railway Company, with a system of nearly 1400 miles, carries the output from the collieries along its line, distant, say, from 350 to 400 miles west of Newport News, its tide-water loading port. The total coal and coke carried by this railroad in 1902 was over 5,000,000 net tons, including splint, block, and cannel coal.

The Chesapeake and Ohio Railroad is a consolidation made in 1868 of the Virginia Central and the Covington and Ohio Railroad Companies. The former railroad was opened from Richmond, Virginia, to Covington, Kentucky, at the base of the Allegheny range, some 208 miles, in 1867. The latter railroad was undertaken—the means being supplied chiefly by the State—for the purpose of extending its railroad system to the Ohio River. A large amount of money was expended when the work was abandoned in 1861, at the beginning of the Civil War. After the close of the war work was again renewed and the whole line completed, from the waters of the Chesapeake to those of the Ohio, March 1, 1873.

The company was reorganized in 1888 under the title of Chesapeake and Ohio Railway. The new company made important extensions to improved tide-water terminals on Chesapeake Bay and westward to the Mississippi River at Memphis, thus fulfilling the object of the projectors of this line,—"to open by the shortest route to the seaboard and to one of the best harbors on the coast the great coal-fields of Virginia and Kentucky, as well as the central portions of the territory of the United States; in other words, to carry into effect the plans so long entertained and prosecuted by the State of Virginia, to carry out which in a manner most favorable to the cheap movement of heavy freights that State expended vast sums of money, the benefit of which, in its favorable line and grades, the road as now completed enjoys."

The foregoing railroads are the principal lines used for the movement of the coals from the mines in the interior to the various shipping ports along our eastern coast. The coal moving westward for consumption in the various States by rail, and south by boats along the great rivers Ohio and Mississippi, is strictly for domestic use, and in no way competitive with any foreign product. That territory is ours,—the natural market for American coals,—and will forever remain so, duty or no duty. But on our ability to transport coals cheaply from the mines to our Atlantic seaboard, over the great lines of railroads whose histories

I have just sketched, will depend entirely the success of our efforts to retain our coastwise trade as against imported coals.

No further reduction in the cost of mining can be looked for, but rather a gradual increase as the cheap upper seams become exhausted and we are compelled to go deeper into the coal-bearing strata for our supply of coal.

CHAPTER XXII.

VESSEL CARGOES.

Some idea of the magnitude of the transportation business performed by locomotives and the cheapening of the same by the introduction of railroads can be gained by the reader in the following extracts from the report of Carroll D. Wright, of March 17, 1886; he says:

"There are in the United States 28,600 locomotives. To do the work of these locomotives upon the existing common roads of the country and the equivalent of that which has been done upon the railroads of the past year would require, in round numbers, 54,000,000 horses and 13,500,000 men! The present cost of operating the railroads of the country with steam power is, in round numbers, $502,600,000 per annum, but to carry on the same amount of work with horses and men would cost the country $11,308,500,000!"

In the "Development of Transportation Systems in the United States" Mr. Ringwalt gives an interesting recapitulation of the various methods employed to move one ton of coal 100 miles, or from the Schuylkill anthracite mines to tide-water at Philadelphia, as follows:

1. To move one gross ton of coal 100 miles by a human burden bearer would require 231 days of labor.

2. To move one gross ton of coal 100 miles on a pack horse would probably require his services for a little more than 50 days, if allowance is made for return trips.

3. To make the movement over a rough country road would require the use of a team and four horses for a little more than eight days, and on a turnpike for a little less than four days, if no allowance is made for a return trip; but with such allowance the time would be materially increased.

4. On a crude railway, like the early Mauch Chunk coal road, a horse or mule could move 57 tons one mile one day. Such labors would be equivalent to carrying one ton of coal 100 miles in about $1\frac{3}{4}$ days.

5. If a superior railway for the use of horse-power could be used and the appliances brought up to what was formerly considered a high standard for such works, and movements equivalent to 240 tons one mile in one day were made, the result would be the performance of labor equal to the movement of a ton of coal from the Schuylkill region mines to Philadelphia in less than half a day.

Then, with a horse railway of a high class, one horse, under such human guidance as might be found necessary, would in less than half a day perform a labor which would require 231 days of the work of a man as a burden bearer.

On all important railways there has been a rapid advance during late years in the weight of locomotives, of trains, and the amount of freight carried. It is difficult to say what can be or is now accomplished. It is known that years ago trains containing from 500 to 700 tons of freight commenced passing over great lines daily, sometimes over distances of 100 miles per day, and occasionally over double that distance. A movement of 500 tons for a distance of 200 miles in one day means the equivalent of 100,000 tons moved one mile in one day, and this is not a difficult feat. At present a number of existing locomotives are capable of drawing more than 2000 tons on a level railway.

Trains carrying an aggregate weight of 1500 tons, including the weight of the engine and cars, are now not uncommon; and some trains are run over favorable grades which carry 1500 tons of freight. That seems to be about the capacity which was, in 1885, regarded as something beyond a usual standard, and yet attainable. The weight of standard freight trains running from Mifflin to

Harrisburg, on the Middle Division of the Pennsylvania Railroad, in 1885 was 2445 tons.

On the railroads mentioned the bulk of the tonnage carried is coal and coke; on several of them it is almost the entire freight movement. For this traffic therefore a great variety of cars have been invented, all of them with one object in view,—the cheapening of transportation and the facility of unloading. In the former chapter on Development the reader has been brought through the various stages of coal mining to the point where the small mine wagons full of bituminous coal were dumped directly into the railroad cars from the tipple, or in the case of anthracite coal from the breaker-chutes into the railroad cars. These latter are of every style and pattern, from the four-wheel "Jimmies" carrying about five tons to the eight-wheel hopper gondola with a capacity of 100,000 pounds. The four-wheel "Jimmies" are made of wood and cost about $200 each; they are gradually disappearing from use. Then there are iron cars with four, six, or eight wheels, with drop or hopper bottom; flat or platform cars with sideboards, as are commonly used for shipments to the lakes, returning laden with ore or other tonnage. The most common form of coal-car for shipment of coal to tide-water is the hopper-bottom gondola of 100,000 pounds capacity, made of steel and having eight wheels. Those cars are equipped with air-brakes and patent couplers, and many of them have painted on their sides the names or initials of the coal operators who own or lease them for their exclusive benefit. A car so designated is known as an "individual" car, and is generally run between the mines and the coastwise shipping ports of the various railroads.

Arriving at tide-water these cars are first weighed and then run out on a pier or wharf and dumped into the holds of vessels waiting to receive them. A vessel having thus received her cargo of coal, she is cleared for the various cities and towns along the Atlantic coast or adjacent harbors.

These vessel cargoes are made up at the following ports, the tide-water terminals of the coal-carrying railroads, as follows:

NORFOLK, on the Hampton Roads, at the mouth of the James River, Virginia. Here, at Lambert's Point, is the loading point of the "Pocahontas" coals, received over the Norfolk and Western Railroad.

NEWPORT NEWS, also on Hampton Roads, is the coal terminus of the Chesapeake and Ohio Railroad.

GEORGETOWN, near Washington, D. C., on the Potomac River, is the shipping point for bituminous coals, transferred from boats of the Chesapeake and Ohio Canal.

Baltimore, at which port is Locust Point, on the Chesapeake, the Baltimore terminus of the Baltimore and Ohio Railroad, and the shipping point for the bituminous coals from the Elk Garden and Cumberland regions, also the gas coals from West Virginia, the Somerset County mines, and the Youghiogheny gas coals of Pennsylvania. The Pennsylvania Railroad makes shipments of its Clearfield coals over the Northern Central Railroad to Canton, which is part of Baltimore.

Philadelphia, which is the nearest to the anthracite and bituminous regions of Pennsylvania, and is connected by the Pennsylvania, Philadelphia and Reading, North Pennsylvania, and Lehigh Valley Railroads. In the northern part of the city is a section known as Port Richmond, on the Delaware River, where the Philadelphia and Reading Railroad has extensive wharves for loading both steamer and sailing vessels with anthracite and bituminous coals. In the southern part is Greenwich, also on the Delaware, the coal terminus of the Pennsylvania Railroad, adjacent to which is the tide-water terminal in Philadelphia of the Baltimore and Ohio Railroad. At Richmond are loaded the anthracites of the Reading and Lehigh Railroads and the Beech Creek bituminous; at Greenwich the Pennsylvania anthracites and the Clearfield bituminous and the gas coals and the Cumberland and West Virginia coals coming east over the Baltimore and Ohio Railroad. The depth of water in the harbor of Philadelphia is ample for vessels engaged in the coal trade.

South Amboy, on the New Jersey coast, at the mouth of the Raritan River, on Raritan Bay, and the principal loading point of the Pennsylvania Railroad for the anthracite, bituminous, and gas coals.

Perth Amboy, situated at the head of Raritan Bay on the New Jersey coast, about twenty-five miles from New York City, and the Lehigh Valley Railroad terminus.

Port Reading, located on the Arthur Kill or Staten Island Sound, about three miles north of Perth Amboy, in New Jersey. This is one of the new terminals of the Philadelphia and Reading Railroad, and is one of the most complete of transfer stations, where the Pennsylvania coals are distributed to New York and other coastwise markets. This terminal is calculated "for the storage and shipment of coal in quantities only limited by the demands of the markets."

Elizabethport, on Staten Island Sound, about fourteen miles southwest of New York. The tide-water terminus of the Central Railroad of New Jersey, together with

PORT JOHNSTON, on the Kill von Kull in Hudson County, New Jersey.

PORT LIBERTY, on New York Bay, one of the shipping ports for the coals transported by the Reading's system.

HARSIMUS: At Harsimus Cove in Jersey City, New Jersey, on the Hudson River, opposite New York City, is the shipping pier of the Berwind-White Coal Mining Company for their "Eureka" Clearfield bituminous coals and "Ocean Westmoreland" gas coals.

HOBOKEN, situated on the New Jersey side of New York harbor, directly opposite the city. This is the terminus of the Delaware, Lackawanna and Western Railroad for tide-water business.

WEEHAWKEN, on the Hudson River, also opposite New York City. Transfers of coal are made here from the cars to vessels by the Erie, Ontario and Western, and the Delaware and Hudson Canal Company's Railroads. It is accessible also to the Pennsylvania Railroad.

PIERMONT, on the Hudson River, twenty-five miles above New York City, is the loading-point for vessels consigned to the Erie Railroad.

CORNWALL, on the Hudson River, fifty miles above New York City, is a water terminal of the Ontario and Western Railroad.

Newburgh, ten miles farther up the Hudson River, is the shipping-point of the Pennsylvania Coal Company.

Rondout, on the Hudson River, is about ninety miles above New York City, and is the shipping-point of the Delaware and Hudson Canal Company.

From the foregoing seaports almost all the coal which is carried to the Atlantic seaboard is reshipped into vessels, and by them carried to destination.

The most common form of transferring the coal from the cars to the vessel is by means of hinged doors in the bottoms of the cars. These are opened and the coal is dropped, by chutes, directly into the vessel's hatches.

In other cases, the coal is first unloaded into great bins or enormous storage-piles or heaps, from which it is afterwards taken in wheelbarrows or by special mechanical devices to the awaiting vessels.

One of the most recent devices for unloading coal-cars into vessels has been in successful use on the docks of the New York, Pennsylvania, and Ohio Division of the Erie Railroad, in the city of Cleveland, for some time past. The machine is the invention of Mr. Timothy Long. The car-dump consists mainly of a large cylinder, with an inside diameter of 11 feet, and an outside diameter of 16 feet, the length being 40 and the circumference 52 feet. It is set 28 feet above the level of the docks, but on a level with the company's tracks, one of which runs through the cylinder when the latter is at rest. The coal-laden car is set in the cylinder by means of a switching-engine; and by the time the car is detached from the train it is clamped firmly by means of a beam running along the side. This beam acts by hydraulic pressure, and the car is held rigid by four iron clamps which fall upon the top of the car's sides, and which are firmly held in place by keys fitting in cogs. These clamps act automatically when the cylinder begins to roll.

This clamping process is the work of an instant, and, by means of a lever worked from the end of the cylinder, an engine on the dock level is started. This engine has a cylinder 30 inches in diameter by 19 feet stroke of piston, and a single stroke is all that is necessary to roll the cylinder up an inclined plane, when the coal rolls out compactly into the chute. When the coal leaves the car the chutes stand out horizontally, which prevents the coal acquiring any momentum. As soon as the cylinder begins to roll back the chutes are gently lowered by means of another engine on the dock level, and operated by a man standing between them, until the coal is allowed to pour gently into the hold, the breakage being thus reduced to a minimum which is something less than when it is handled by being shovelled into buckets and then dumped into the vessel hold.

This machine is designed for cars having no "drop bottoms."

CHAPTER XXIII.

DOMESTIC COALS.

"When the fire on the hearth has blazed up and then settled into steady radiance, talk begins."

We have come to the domestic part of the story, the times of our fathers' youth, when "the fire rests upon the broad hearth, the hearth rests upon a great substruction of stone, and the substruction rests upon the cellar . . . those good old days when it was thought best to heat the poker red-hot before plunging it into the mugs of flip. . . . The backs and jams are built up of great stones, not always smoothly laid, with jutting ledges upon which ashes are apt to lie. The hearth-stone is an enormous block of trap-rock, with a surface not perfectly even, but a capital place to crack butternuts on. Over the fire swings an iron crane, with a row of pot-hooks of all lengths hanging from it. It swings out when the housewife wants to hang on the tea-kettle, and it is strong enough to support a row of pots or a mammoth caldron kettle on occasion. What a jolly sight is this fireplace when the pots and kettles in a row are all boiling and bubbling over the flame and a roasting spit is turning in front."

That is Charles Dudley Warner's picture of an old New England farm-house, when they burned "hickory wood cut long," with the large back-log, "which does not rest on the andirons," and fore-stick on the andirons with the lighter stuff.

The coal barons ought to suppress the "Back Log Studies." It has done more towards retarding the growth of the trade in domestic sizes of anthracite coal than any other book in American literature. Even to this day, in the full light of modern electricity, fuel-gas, and the forced growth of steam-radiators, there are men who have a fireplace,—away off in an obscure "den," perhaps, but still part of the house,—and are fire-worshippers in the most bigoted sense of the word; they will sit there by the hour gazing into the crackling blaze of the aromatic logs and swear by all the past that there is nothing in life to compare with its cheerful heat and comfort.

But "it must be confessed that a wood fire needs as much tending as a pair of twins."

In 1749 the number of cuts to be made in a log of firewood, in Philadelphia, was determined by an ordinance,—"that it should measure four feet in length or be forfeited to the poor, and any person refusing to submit it to measurement should forfeit five shillings per cord."

There were no wood-yards then, or coal-yards, for the retailing of fuel, but "great quantities of wood used to be brought to the city on sleds in the winter and sold,—very high,—sometimes $15.00 to $16.00 a cord." Which must have been to the rich or improvident, for it was the custom to fill the wood-house in summer with the same regularity as the ice-house in the winter. Some of us are not so young that we cannot remember both the wood-house and the ice-house, and every well-regulated family in the country had both.

Later we are told, in "Watson's Annals," "Since the practice of laying up wood *in yards* has prevailed, the winter prices are much moderated." This was the beginning of the retail wood-yard and coal-yard. The wood was delivered to the customers' dwellings in four-foot lengths, and an itinerant came along with a saw and cut the wood into any desired length on the premises.

Then came an occasional cargo of sea-coal, or bituminous, imported in sailing vessels, "making foul, sooty smoke and pasty, trashy residuum, yet withal, making flame that is pleasantly sparkling, dancing, prettily waving, and leaping like a roebuck from point to point." Much of this coal came from the Virginia mines near Richmond, and the retailer in the seaboard cities stocked his yard with "choice imported and domestic coals."

This was long before anthracite was known.

"No regular sale of anthracite coal was effected in the Philadelphia market till the year 1825." In 1820 the old Lehigh Coal Company had succeeded in getting 365 tons to Philadelphia "as the first-fruits of the concern," and we are informed that, "little as that was, it completely stocked the market and was sold off with difficulty!" Mr. Watson adds: "It increased each subsequent year up to 1824, making in that year a delivery of 9541 tons. In 1825 it ran up to 28,393 tons and kept along at nearly that rate until 1832, when it delivered 70,000 tons. From that time it went regularly on increasing, until now, in 1839, it has delivered 221,850 tons. And now that it has got its momentum, who can guess where it will end!"

Who, indeed?

We record 50,000,000 tons of anthracite for 1904, and the next writer on coal will smile at our figures.

Years ago Bryant wrote the following "Meditations on Rhode Island Coal." It was thought at the time to forecast the development of the New England anthracite, which gave promise of great things:

"Dark Anthracite! that reddened on my hearth,
Thou in those island mines didst slumber long;
But now thou art come forth to move the earth,
And put to shame the men that mean thee wrong.

Thou shalt be coals of fire to those that hate thee,
And warm the shins of all that underrate thee.

"Yea, they did wrong thee foully—they who mocked
Thy honest face, and said thou wouldst not burn;
Of hewing thee to chimney-pieces talked,
And grew profane, and swore, in bitter scorn,
That men might to thy inner caves retire,
And there, unsinged, abide the day of fire.

"Yet is thy greatness nigh . . . thou too shalt be
Great in thy turn, and wide shall spread thy fame
And swiftly; furthest Maine shall hear of thee,
And cold New Brunswick gladden at thy name;
And faintly through its sleets, the weeping isle
That sends the Boston folks their cod shall smile.

"For thou shalt forge vast railways, and shalt heat
The hissing rivers into steam, and drive
Huge masses from thy mines, on iron feet,
Walking their steady way, as if alive,
Northward, till everlasting ice besets thee,
And south as far as the grim Spaniard lets thee.

"Thou shalt make mighty engines swim the sea
Like its own monsters—boats that for a guinea
Will take a man to Havre—and shalt be
The moving soul of many a spinning-jenny,
And ply thy shuttles, till a bard can wear
As good a suit of broadcloth as the mayor.

"Then we will laugh at winter when we hear
The grim old churl about our dwellings rave.

> Thou, from that 'ruler of the inverted year,'
> Shalt pluck the knotty sceptre Cowper gave
> And pull him from his sledge, and drag him in
> And melt the icicles from off his chin."

Credit is usually given to Judge Fell, of Wyoming, for being the first to use anthracite coal for domestic purposes and in a grate, which he specially designed. It was thought necessary to use bellows to blow the fire. This was in the year 1808.

In 1814, Messrs. Miner, Cist, and Robinson, all of Wilkes-Barre, renewed the enterprise at Summit Hill (Mauch Chunk) with great energy. "On the 9th of August," says Mr. Greene, "they started their first ark-load of coal down the river to Philadelphia. Before it had gone eighty rods from the place of starting it struck a ledge which tore a hole in the bow of the boat, 'and,' Mr. Miner says, 'the lads stripped themselves nearly naked to stop the rush of water with their clothes.' After many and varied adventures on the swift currents of the rivers, the ark reached its destination on the following Sunday morning at eight o'clock, having been five days on the way. Its arrival had been anticipated by its owners, and they had called public attention to its cargo by means of handbills printed in both English and German and distributed freely throughout the city.

These hand-bills, besides advertising the coal, gave information as to the method of burning it in grates, stoves, and smiths' forges. They were also accompanied by printed certificates from blacksmiths and others attesting the value and availability of the Lehigh coal as a fuel. The owners of the ark went still further. They put up stoves in conspicuous public places in the city, built coal-fires in them, and invited the people to stop and inspect them. They attended at blacksmiths'-shops and even bribed the journeymen to give their coals a fair trial." Twenty years later the use of anthracite coal in stoves was quite common in the more populous towns. Bowen writes: "It was at this period that scenes of excitement, speculation, and daring enterprise were enacted which surprised and startled our good old Commonwealth (Pennsylvania) from its Quaker propriety. Capitalists awoke as if from a dream, and wondered that they had never before realized the importance of the anthracite trade! What appeared yesterday but as a fly now assumes the gigantic proportions of an elephant! The capitalist who, but a few years previously, laughed at the infatuation of the daring pioneers of the coal trade now coolly ransacked his papers and ciphered out his available means, and whenever met on the street his hands and pockets would be filled with plans of towns, of surveys of coal lands, and calculations and specifications of railways, canals, and divers other improvements now unheard of! The land which yesterday would not have commanded the taxes levied upon it was now looked upon as 'dearer than Plutarch's mine, richer than gold.' Sales were made to a large amount, and in an incredibly short space of time it is estimated that upwards of five millions of dollars had been invested in lands in the Schuylkill fields alone!"

The use of anthracite coal in the cities of the seaboard had been greatly stimulated by the war with Great Britain, which prevented an importation of the foreign coals, and also interrupted the shipments of bituminous coal from the Richmond fields.

Lehigh coal was selling at $14.00 per ton, and the means of transportation were receiving the attention of the best engineers in the country. It was calculated that the domestic requirements of the nation would be something enormous, and that buyers would all prefer the use of anthracite coal; but it was found, after the peace was concluded, that the foreign and other bituminous coals could be sold cheaper, and at a price that would not pay for the labor of mining and shipping the anthracite.

By degrees, however, the cost of mining was reduced, and, more important, the means of transportation were so much improved that the difference in the price of the two fuels was not so great, while the advantages of a clear, steady, cleanly fire, with freedom from the heavy, black smoke of the foreign coals,—with perhaps a good-sized "chunk" of patriotism thrown in,—were sufficient, finally, to induce people to use the Pennsylvania anthracite, and so to overcome another obstacle to its successful development. Its use is now almost universal in the Eastern towns and cities for domestic purposes,—so much so, in fact, that any attempt on the part of the producers to raise the price is resented by the press and the forum as a "public calamity," a "tax on the necessities of life," and other like phrases, which sound ridiculous when we reflect on the price ($2.65 per ton) at which bituminous coal can be sold in Philadelphia and the enormous amount of this kind of coal which we possess.

Anthracite coal is no more a necessity of life than is young hickory wood, and its price for domestic use can be raised just to the point when people won't use it, and no higher. Our boundless and inexhaustible supplies of every other variety of fuel, distributed over nearly every State in the Union, will forever prevent any concerted action that would exact exorbitant prices for anthracite coal. It is no more a "necessity of life" to the American people than it is to the English, French, and German nations, where its use is comparatively unknown. When we read of the strenuous exertions made by the use of every inducement, including bribery, to force the use of anthracite coal upon the public, it does not seem a formidable undertaking for the public to again use bituminous coal, as they did in former years. The greatest retarding factor of this economic movement will be the more or less hysterical legislation of municipal authorities against what is commonly known as "the smoke nuisance"—laws fostered in ignorance of the common rules of combustion and encouraged by the enormous wealth and influence of the Eastern anthracite interests.

CHAPTER XXIV.

POCKETS, DEPOTS, AND YARDS.

THE coal having arrived at destination on the lakes or the Atlantic seaboard, and the retailer fully supplied, the manufacturer filled up, and no buyers in the market, the miners would have to suspend operations until the stock had been used. For many reasons this would be inconvenient and costly. During certain seasons of the year a mine can be worked more cheaply than at others; and periods occur when, from labor troubles, accidents by fire or water, or violent storms interrupting the transportation systems of the country, the movement of the great black stream of coal is greatly retarded, and perchance for several weeks might be stopped entirely.

To balance any such irregularity large reservoirs—if one may use the term—of coal are kept constantly full at some convenient points on the coast line, which are used as depots to regulate the flow of coals from the mines to the consumer.

The largest coal depot in the world is located in New Jersey. It is the coal-storage ground of the Lehigh Valley Railroad at South Plainfield, where is dumped the output of the company's big mines in the Lehigh and Wyoming Valleys of Pennsylvania.

The coal market is one of the most uncertain things in the world, as it is positively impossible to estimate on the output at any time, and the object of this storage is to always have coal ready for the market. The site is an ideal one for the purpose. The railroad company owns a tract of about 125 acres, which is situated in the angle between the Lehigh Valley main line and the Perth Amboy road, a branch, and about fifty acres are utilized for the storage grounds. As regards situation no better place could be found, lying as it does on the branch road on which about 80 per cent. is finally transported to Perth Amboy, where it is shipped by boat to New York and points on the Long Island shore and along the New England coast. At the same time it is within half a mile of the main line, with which it is connected by a single track spur to the east reaching to Oak Tree, and which brings it within easy access of Newark, Jersey City, and even New York again, besides the points *en route.*

These dumps are marvels in size, simplicity, and strength. There are fourteen, with the following capacities: six holding 30,000 tons each, two holding 20,000 tons each, four holding 15,000 tons each, two holding 10,000 tons each,—with a total capacity of 300,000 tons. The estimated value of the coal, when these dumps are full, is over $1,000,000.

The dumps are made of two self-supporting steel trusses, which make an obtuse angle, the largest being 85 feet high, with a spread at the base of 250 feet. The dumps are arranged in two rows of seven each, with a railroad running through the centre. These tracks are about six feet above the surface of the ground. Under the tracks and alongside the dumps are bins, known as "pockets." The cars come along the track, and when they get over one of the pockets the "gate" or bottom of the car is removed, and the coal falls through the ties into the bin, about the same as in a coal-yard. This bin tapers down to the bottom into a trough about eighteen inches or two feet wide. This trough runs out to and up one side of the truss to the centre. Through the trough is an endless chain, fastened to which are pieces of sheet-iron which fit snugly in the trough. They are about two feet apart, and as they pass through the bins they drag the coal along with them to and up the trusses. This unloading is done at the rate of about 120 tons per hour.

The coal is not all dropped from the top or centre of the trusses, as that would break it too much. The trough is fixed so that it can be regulated to let the coal drop from different distances. It is started at a few feet from the ground, and when a cone is formed which nearly touches the trough, the outpour is stopped at that point, and another hole is opened a little farther up, and so on until the cone reaches the highest point, when it forms one immense mountain of coal.

The reloading is on the same principle as the unloading. A big raft is swung up to the side of the pile on tracks laid on the ground. The raft is about two or three feet high, about six feet wide, and is as long as the diameter of the heap at the base. Around this raft there is a steel construction about two feet wide, projecting beyond it as the brim projects beyond the crown of a hat. An endless chain goes around, sliding on the projection and dragging the coal, which keeps sliding down against the raft. At the base of the truss another trough begins, and the coal is then lifted to a tower a few feet higher than the coal-cars. While passing through the tower it is screened and comes out on the other side, and is conducted to the car in a chute.

The actual time of loading one of the four-wheel cars is one and a half minutes. It takes about half a minute to take the car away and get another one under, so that the loading goes on at an average of about 150 tons per hour, or 28 four-wheel cars, or seven of the big eight-wheel bodies. Altogether there are seven men employed at the reloader, which gives an idea of the labor-saving qualities of the machinery.

A pair of scales 55 feet long is arranged on the track opposite the office, and when the cars are loaded they are sent over the scales two or three at a time, and their weight is taken as they pass over. The coal is then ready to be shipped.

Provision is also made for the storage of bituminous coal in "pockets" at all the larger towns and cities. A fair example of many is a plant for handling coal recently installed by the Jeffrey Manufacturing Company, of Columbus, Ohio, for the Kineon Coal Company, of Cincinnati, Ohio. The lump-coal is dumped from the cars on tracks above the storage pockets. As this lump-coal is delivered to wagons it is screened in the chutes, the nut and slack being taken out and binned under the pockets. From these bins it is loaded into tram-cars of two tons' capacity operated on tracks beneath the pockets. These cars are emptied on both sides of the building into hoppers. Connecting these hoppers with the elevator boots, fourteen feet below the surface of the ground, are screw conveyors of heavy build and capacity to feed the elevators. The elevators are of the continuous bucket type, with massive wrought-steel buckets securely bolted to a wrought-steel chain of a new and improved type recently put on the market by the Jeffrey Company. These elevators spout coal either to pockets, from which it is delivered to wagons for distribution, or direct to cars on the overhead tracks. The power to drive the machinery is transmitted by manila rope transmission, the engine and boiler being at the extreme south end of the building. Friction clutches conveniently placed give the operator perfect control of the driving machinery. In every detail the plant is built with a view to giving great strength, durability, and capacity, either elevator handling two tons of slack coal in forty-five seconds at a nominal speed, which capacity can be increased as necessity demands.

From the "storage" piles and "dumps," from the "pockets" and "depots," the coal is supplied to the familiar coal-yard, and from there is delivered by carts and horses to the cellars of the householders or to the bins of the corner grocers, from whence it trickles in smaller streams by buckets, and even by shovels, to the tenements of the poor.

The larger coal-yards receive direct by rail unbroken car lots direct from the mines, many of them having a storage capacity equal to a depot or pocket.

A thoroughly modern coal-yard is that comprised in the plant of the Weehawken Wharf Company, at the foot of West Thirty-eighth Street, New York, which was recently opened for business to supply coal to the dealers.

It is located at the northwest corner of Eleventh Avenue and Thirty-eighth Street. About fifty feet north of the corner, one end of the pocket abuts directly upon the sidewalk of the avenue. The corner affords position for a commodious brick office building, and north of that is a double drive-way with a wooden flooring, extending the entire length of the pocket, a distance of 300 feet. At the street end is a brick scale-house and weighing-office with three 15-ton scales. The pocket is constructed of a steel framework with wooden sides, floor, and roof of heavy timber. The width is 28 feet and the height 40 feet.

There are 17 bins with a capacity of 300 tons each, a total of 5100 tons. The bins are generally kept as full as possible, in order to avoid breakage when coal is dumped into them. Five chutes lead from each bin, two terminating over the outside drive-way, and the other three at one side of the tunnel which traverses the structure. Screens are fixed beneath the outlet of each chute, insuring clean coal for delivery, the dust and screenings falling from these being collected in a small bin below, from which they will be gathered by a conveyor. The great demand for small coal in the vicinity of the plant for steam purposes renders it quite profitable to carefully collect all screenings.

Having noticed the arrangement at the front end of the yard, the next step is to see how the coal arrives. It comes in cars upon floats from the several railway terminals on the New Jersey side of the river. These are drawn off at the foot of West Thirty-seventh Street by an engine which is always at work in the freight yard at that point. This locomotive switches the cars a few hundred feet and places them at the foot of an incline extending to the top of the pockets. The cars are drawn up this incline by a wire rope attached to a huge "dog" which, rising from a pit beneath the track of the slope, attaches itself to the rear of the cars. Arriving at the top the car is drawn by a separate wire rope and winding engine to whatever point it is desired to place the coal. The hatch cover is then taken from the bins, and the coal is dumped from the bottom of the car directly into the bin. The plant is arranged for work after dark by a thorough system of electric lights supplied by a dynamo on the premises. Ample steam power is maintained, and attachments have been made to the boilers by which steam can be drawn off in pipes to thaw out frozen coal in the bins whenever found necessary.

When the transportation of coal extends beyond what is known as the "line and harbor delivery" —that is, to points on the lines of the transporting railroads or the cities on the coast to which they deliver unbroken car lots—the coal is taken in the original cars to the tide-water terminals of the different railroads, and their contents are dumped into vessels or barges and conveyed by them to any point on the Atlantic coast line. These shipments are known as "tide-water deliveries," and the coal arriving at its destination must be hoisted from the hold and landed on the retailer's dock or into awaiting railroad cars for transportation to the interior.

This work was formerly done by coal-heavers, whose daily average was about five or six tons each, afterwards horse-power was used with ropes and pulleys, and then the steam-engine was used with gravity railroads. The coal was raised to the top of an elevated structure and dumped into a small car which ran by gravity to the coal pile and dumped automatically. The empty car was drawn back by means of a weighted rope which the loaded car had raised on its downward journey.

These automatic railways will handle 50 or 60 tons of coal an hour.

The unloading of coal-laden vessels is still further expedited by means of steam-shovels, like enormous clam-shells, which scoop up from one to three tons of coal at each descent, and then, closing their jaws, carry the big mouthful safely ashore, where they disgorge at the will of the operator. The use of this machine increases the capacity of one man from an average of five or six tons to 150 or 200 tons daily, at a cost of about three cents per ton.

When the coal is to be carried some distance from the wharf, cable-roads are used, the loaded cars being attached by grips, discharged automatically at destination, and returned empty for reloading. The Hunt conveyor, with rows of iron buckets hung to endless parallel chains, is another improved method for handling coal rapidly.

In coaling or "bunkering" ocean steamers, the coal is floated to the steamer side in large barges, and a floating elevator is run between the barge and the vessel, which hoists the coal directly into the bunkers.

PART IV

CONSUMPTION

CHAPTER XXV.

BITUMINOUS STEAMING.

BEGINNING with the origin of coal, I have sketched its wonderful development in the United States, and described the various means employed in transporting the resultant tonnage from the mines to the seaboard.

It is now in order to give the various uses to which the different varieties of coal are put in common usage, together with such explanations as may be of benefit to the consumer. Percy describes the word "fuel" as used to denote substances which may be burned by means of atmospheric air, "with sufficient rapidity to evolve heat capable of being applied to economical purposes. There are only two elements which are thus applied, namely, carbon and hydrogen. All fuel consists either of vegetable matter or of the products of the natural or artificial decomposition of that matter. Vegetable matter which chiefly consists of woody tissue may practically be regarded as composed of carbon, hydrogen, and oxygen, together with a small quantity of so-called earthy matter. The former constitute the organic and the latter the inorganic part of vegetable matter. The original sources of the organic part are water, and, except in particular cases, the carbonic acid of the atmosphere, both of which are decomposed in the economy of plants by the action of solar light. The sun, therefore, is really the source of heat-producing power of fuel."

A unit of heat is the quantity of heat required to raise the temperature of one pound of water from 39° to 40° Fahrenheit.

Dr. Joule, of Manchester, England, after many experiments, fixed the mechanical equivalent of one unit of heat at 772 pounds raised one foot high,—*i.e.,* foot-pounds.

A pound of coal contains 14,500 units of heat. If we would get at the working energy of one pound of coal, it is equal, therefore, to the product of 14,500 x 772, or 11,194,000 pounds raised one foot high in one minute.

A foot-pound, or the unit of work, is the energy exerted in raising or lifting one pound in weight one foot high in one minute.

Thirty-three thousand pounds in weight raised or lifted one foot high in one minute is called a horse-power.

These give us some idea of the amount of latent force contained in a pound of coal. Such work, of course, can never be arrived at in practical use, but the energy is there, all stored up for whatever purpose we choose to invent.

If a piece of Pennsylvania semi-bituminous coal from the Clearfield region, such as is used for steaming-purposes, is divided into its component parts, about 78 per cent. of the whole would be fixed carbon, 18 per cent. would consist of volatile matter, and the balance, or 4 per cent., would contain the ash and what are called the impurities of the coal.

The first-named part, fixed carbon, is one of the most common of the elements. The diamond, black lead, and charcoal are pure carbon, and the increased amount of it occurring in anthracite coal denotes the chemical difference between anthracite and bituminous. Carbon produces heat and, chemically speaking, anthracite coal would produce more steam than bituminous, and black lead than either, but in practice such is not the case.

The volatile matter or combustible gases contain hydrogen, nitrogen, and oxygen. The combustion of these gases is seen in the flame. When a coal contains as much as 18 per cent. of volatile matter it is called semi-bituminous, although there is no bitumen in its composition. Bitumen is a mineral pitch in various degrees of density from naphtha to asphalt. The oily substance which sometimes exudes from burning coal closely resembles bitumen.

Hydrogen is also a combustible element, a gas when in its free state and one of the constituents of water, the other being oxygen. Owing to the small amount contained in coal, its presence does not contribute materially to the units of heat.

Nitrogen is the principal constituent of the atmosphere and has no part in the combustion of coal. It is lighter than air, and "by virtue of its lighter gravity assists in maintaining a good draught."

Oxygen is heavier than the air; it forms eight-ninths of water and nearly one-fourth of air, and is the principle of all ordinary combustion.

Sulphur is almost always present in coals, but in various forms. The familiar one of iron pyrites is well known to every miner in the shape of flat pieces of brass-like substances occurring in layers, sometimes no thicker than paper, and again from one-quarter to half an inch; it is highly inflammable, and burns with a clear blue flame. It is an enemy to steam boilers and grate bars.

Ash is the inorganic matter of coal, and is incombustible. It is the earthy matter in the drift of the coal period, and consists of silica, alumina, lime, and oxide and bisulphide of iron, the silica and alumina constituting from ninety to ninety-five per cent. of the whole. The commercial value of a coal is largely dependent on the amount of ash which it contains, and also the kind of ash produced in combustion. If sulphur, in the form of iron pyrites, is present in the coal, the ash will be of a red color, and its continued use in a furnace will destroy the grate bars.

Frequently also the ash will melt and run together in a soft mass which adheres firmly to the bars and clogs the draught, preventing combustion. When this mass cools it forms an exceedingly hard clinker, difficult to remove and corroding the iron. The less a coal clinkers the better it is for making steam. For this reason the white-ash coals are the best, the color denoting the absence of iron pyrites. On the other hand, the rapid combustion of white-ash coal will cost the consumer more for his fuel than a more refractory coal containing a larger amount of ash and burning more slowly.

Water: all coals contain moisture or water,—the semi-bituminous coals from one-half to one and one-half per cent.; it does not aid in combustion, and is evaporated and expelled at the cost of heat.

A typical analysis, therefore, of a good semi-bituminous steaming coal from either the Cumberland region of Maryland or the Clearfield region of Pennsylvania would be as follows. It is an average analysis of ten well-known high-grade fuels:

Fixed carbon..................	78.00	per cent.
Volatile matter (hydrogen, nitrogen, oxygen)................	18.00	per cent.
Sulphur	.50	per cent.
Ash (white)..................	3.00	per cent.
Moisture (water)..............	.50	per cent.
	100.00	

I use the term "a typical analysis" advisedly, for while the foregoing proportions indicate a good steaming coal, the same constituents might be found in a coal while its principal structure is poor. The chemical analysis is not always a safe guide in selecting coals, although the results in combustion are generally indicated by the laboratory tests. The customer should be guided in this matter by an actual trial of the coal in his own furnace or kiln, and, having ascertained the kind that suits his purpose best, to stick to it, in spite of the interested arguments of the multitudinous middle-men.

If an actual trial is not convenient or is impracticable, and the analysis presented is believed to be trustworthy, the customer should note the following points:

For small boilers, where the fire-box is small and the draught poor or natural, a white-ash, semi-bituminous coal, high in carbon and low in sulphur and ash, will give the best results. Such a coal is indicated in the analysis given above.

For larger boilers, with plenty of grate surface and a good or artificial draught, a coal lower in carbon, higher in volatile matter, and higher in ash can be used with more economy, as the combustion will not be so rapid. A coal high in volatile matter produces a long flame, and should be selected for brick-burning, and a coal low in ash for glass-works.

Sulphur in coal does not necessarily interfere with combustion, but, on the contrary, assists it, as sulphur is highly combustible; but the combination of sulphur, reduced by combustion to oxide of iron, with the potash, soda, lime, and silica,—the inorganic matter of coal,—forms a clinker which will stick to the grate bars and interfere with the draught. It is well, therefore, to see that this troublesome element does not exceed one per cent. as the limit allowed in the analysis.

The foregoing remarks apply to the semi-bituminous steaming coals of Pennsylvania, Maryland, and the Virginias, which are shipped eastward along the Atlantic seaboard. In this territory they stand for the best fuel for steaming purposes found in this country, and are used for locomotive-firing, ocean steamships, and large manufacturing concerns from Maine to Georgia.

The low prices at which these superior coals have been sold have prevented the importation of Nova Scotia coal into New England; but these prices have not been remunerative to the operating or transporting railroads, and the efforts now being made to obtain a fair price for both coal and transportation may stimulate the development of these Nova Scotia mines to such aggressive activity that a higher tariff will be necessary to protect our own industries.

Nova Scotia coals cannot be ignored as of "inferior quality," as they contain as great a variety in analysis as our own. For example, I have one before me as follows, Cape Breton (Gilpin):

Carbon	58.74	per cent.
Volatile matter	37.26	per cent.
Ash	3.25	per cent.
Moisture	.75	per cent.
	100.00	

Which would indicate a fairly good quality of gas coal; certainly a very "heavy" steamer, and a formidable competitor against our "lighter" Clearfield and Cumberland products for either locomotive or steamship use.

In all discussions relative to Nova Scotia coal, particularly when illustrated with "statistics" showing by figures that the imports of this coal have not increased under the present low tariff, it should be remembered that during this same period the American semi-bituminous coals competing for the New England market have sold *at a price which it is impossible to maintain without ruin to the operators and the coal-carrying railroads.*

If this great industry is to be made a paying one the prices of seaboard coals must be advanced to a point where the present protective tariff does not protect. The remedy is in the hands of the American people, and when they become convinced of the necessity it will be applied in the shape of a tariff sufficiently high to cover the increased cost of transportation to the seaboard over that paid on coals coming from Nova Scotia.

There are two other substances found in semi-bituminous coal, one of which need give the consumer no uneasiness,—mother of coal and phosphorus.

In examining a piece of bright, semi-bituminous coal it sometimes occurs that the piece contains thin partings of a dull black substance, which the observer almost invariably pronounces to consist of slate. More often this substance is the "mother of coal," and is often as highly combustible as charcoal. It can generally be distinguished from slate by scraping with the point of a knife. Slate is hard and gritty; the mother is soft and woody. Its presence in coal generally indicates a good quality.

Phosphorus in coal usually occurs in very small proportions, and is found in the ashes. It is impossible to eliminate it from the coke, and in furnace use the entire amount contained in the coal passes into the pig iron. Manufacturers of Bessemer steel should ascertain by analysis the amount of phosphorus in the coal or coke they use, as the entire amount will be found in the iron produced.

CHAPTER XXVI.

ANTHRACITE—STEAMING.

In strong competition with the semi-bituminous coals for steaming purposes on the Atlantic seaboard are the famous anthracites of Pennsylvania. The relatively short distance from the mines to tide-water which these coals are hauled enables the anthracite operator to obtain a higher price at the mines than can be obtained on the semi-bituminous coals coming a much greater distance, but this difference in hauling is about equalized by the increased cost of mining.

If we divide a piece of anthracite coal into its component parts, as we have done with the semi-bituminous coals, about 90 per cent. of the whole would be fixed carbon, only about 4 per cent. would be volatile matter, and the balance, or 6 per cent., would contain the ash and sulphur.

I have given an explanation of the element known as carbon, and have also named the different parts constituting the volatile matter,—viz., hydrogen, oxygen, and nitrogen, and the ash and sulphur. For comparison, I introduce an analysis of Pennsylvania anthracite, which may be regarded as a typical one, as follows:

	Per cent.
Fixed carbon	87.00
Volatile matter	3.50
Sulphur	.65
Ash (white)	5.90
Moisture (water)	2.95
	100.00

It will be noticed that the carbon is greatly in excess and the volatile matter much less than the semi-bituminous.

Theoretically, anthracite should be as much better than the semi-bituminous as it exceeds that fuel in fixed carbon. But this is not the case. Either from the difficulty of combustion or the mechanical appliances at present in use for generating steam, the excess of carbon is not utilized, and, generally speaking, a ton of semi-bituminous coal will generate as much steam as an equal ton of anthracite. In determining this, it must be understood that the tests should be made in furnaces particularly fitted for each kind of fuel.

The following summary of advantages and peculiarities of anthracite coal is from W. H. Barr:

"True anthracite, when pure, is slow to ignite, conducts heat very badly, burns at a very high temperature, radiates an intense warmth, and is difficult to quench. Generating almost no water during its combustion, it powerfully desiccates the atmosphere of an apartment in which it is burning. Hard anthracite, from its great richness in carbon and its density, stands at the head of all coals for its heat-generating power, if adequately supplied with air. It is the most economic of all fuels —weight for weight—for smelting and melting iron and the other metals.

"The superior density of hard anthracite over every other kind of coal, by lessening the room demanded for storage, gives it a decided preference in this respect as a fuel for ocean steamers.

"In burning, it neither softens nor swells, and does not give off smoke; the flame is quite short, and has a yellowish tinge when first thrown upon the fire, which soon changes to a faint blue, with occasionally a red tinge. The flame, being quite short and free from particles of solid carbon, has the appearance of being transparent.

"When broken, it presents a conchoidal appearance, and appears quite homogeneous in structure. It will stand weathering and stowage better than other coals."

The use of coal for locomotives is of very recent date in the United States.

All the early locomotive works of this country labored under disadvantages or impediments to radical improvements which were gradually removed, to a considerable extent, shortly after 1850, and which, on some lines, had been partially overcome previous to that time. They arose partly from the fact that on a very large proportion of the lines, and, indeed, nearly all, wood was the only fuel used. An English expert, who visited this country shortly before 1850, said that American engines labored under a manifest disadvantage, because, "wood being the fuel used, they are obliged to carry a high, large, top-heavy chimney, with a cumbrous spark-catcher, very different from the small, slight chimney of an English engine. It acts against the engine, not only by its size, but also by the great leverage the heaviest part, the top, has from the centre line of the whole machine."

A remarkable illustration of the tardiness with which coal-burning locomotives were adopted is furnished by a report made by George W. Whistler, Jr., in April, 1849, to John Tucker, then president of the Reading Railroad, in regard to the use of anthracite coal by the locomotives running on that line. As it was then the great coal railway and the great freight carrier of the country, it was particularly desirable that its engines should burn anthracite, but only a very small proportion of them were doing so at that time, and the report relates to a variety of inquiries and experiments instituted for the purpose of ascertaining and surmounting the difficulties which had prevented the general adoption of anthracite as the fuel of the locomotives used on the Reading Railroad. The facts stated include the following: The very earliest of American locomotives of the type designed by Peter Cooper and Phineas Davis used anthracite coal on the Baltimore and Ohio Railroad without serious difficulties, but this was attributed mainly to the fact that they had vertical boilers; and when attempts were made to use anthracite on engines with horizontal boilers various obstacles arose which had only been fully surmounted on the Beaver Meadow and Hazleton roads. Success on those lines, however, was attributed to the fact that they were very short (each being only fourteen miles in length), and consequently operations upon them did not require the intense and continuous heat, which was a leading obstacle to the use of anthracite on long lines, inasmuch as this heat necessitated frequent and expensive repairs. The report stated that "the principal item of excess in the cost of repairs for engines burning coal over those burning wood, is caused by the destructive effects of a coal fire upon the inside sheets of the fire-box; and when iron (the soundness of which is always uncertain, from the manner in which it is at present made) has been used entirely for fire-boxes, this intense local heat has very soon blistered and burned away the sheets in the immediate vicinity of the coal fire. Another destructive effect from the use of coal is its severity on the laps or joinings of sheets in the fire-box. . . . The occasional melting of grate-bars, the increased liability to leakage, the wear and destruction to the ends of tubes by caulking, etc., and the accumulation and igniting of fine coal in the smoke-box, all produce their share of extra expense for repairs over wood-burning engines.''

On the Baltimore and Ohio Railroad, previous to the date of this report, various experiments had been made with engines that respectively burnt wood, anthracite, and bituminous coals, and the conclusions based on these experiments, together with various other conclusions, led Mr. Whistler to recommend that persistent efforts should be made to insure the substitution of anthracite-burning for wood-burning locomotives on the Reading Railroad, remedies being suggested for the difficulties that had been developed.

It was reserved for subsequent decades to witness the general introduction of coal-burning engines, and in 1850 Ross Winans, of Baltimore, was the principal builder of such locomotives. To-day locomotive or ''supply-coal,'' amounting to about 50,000,000 tons annually, constitutes a very large proportion of the annual contracts made by the American operators, and is also probably the largest single item of expense in the operation of our railways.

Some of the larger railroads will use over a million tons of supply-coal annually, which is usually contracted for a year ahead, in order to obtain the lowest possible price and to insure regular deliveries. Of the steam coals previously mentioned, the semi-bituminous coals of Pennsylvania, Maryland, and the Virginias, or the hard anthracites of Pennsylvania, much diversity of opinion exists among railroad officials as to which is the best fuel for locomotives. There is no doubt that the semi-bituminous is the most economical, owing to its extremely low cost and its more easy and perfect combustion. A semi-bituminous coal fire is easily managed by a fireman, and if the better grades are used there is very little waste from ashes or clinkers. An anthracite fire requires much more care, burns with a fierce heat, and generates more ashes and clinkers. Besides which its cost is from 25 to 30 per cent. higher—sufficient to class it as a luxury suitable only for express or passenger trains, where the smoke from the soft coal is an objectionable feature.

No such objection to semi-bituminous coals exists for freight locomotives, and its use for this purpose is almost universal.

Other large consumers of our semi-bituminous coals are the ocean steamers plying between our ports and all parts of the world. With them, as with railroads, the principal item of expense is "supply-coal." One of these "ocean greyhounds" will take 2500 tons of coal to fill her bunkers. In consuming this large amount about 100 furnaces are used for the boilers. These are run at a pressure of 160 pounds. Cochrane states:

"Each of the main boilers contains a mile and a quarter of tubing, or a total of fifteen miles of tubing for the ship. There is a funnel or smoke-stack for each of the groups of boilers, and the size of them gives some hint of the combustion below. They are made oval in shape, so that they may present the narrow surface fore and aft, reducing the loss from wind pressure, and are 13 by 19 feet in diameter and over 100 feet in length!" These boilers have a capacity of 30,000 horse-power.

Coals are delivered to these steamers at the various terminal ports, as described in a previous chapter.

Besides the ocean greyhounds and "liners" there is a large fleet of "tramp" steamers and "coasters" dependent on the semi-bituminous coals of our country for the necessary energy to propel them across the great waters, while myriads of tugs and ferry-boats in our harbors add to the long list of steam producers using this coal almost exclusively.

In but ten States in the Union is the consumption of anthracite greater than that of bituminous. In half of these the consumption of both coals is about equal—anthracite being slightly ahead. In every other State the consumption of bituminous coal is far greater than anthracite.

Regarding the *washing* of anthracite coal at the colliery, the following is an accurate description: "One of the most interesting features of the entire Exeter plant is the coal washery. It is, we believe, the only one of the kind in the Wyoming region. There are other washeries used for working over culm piles, but not one that washes coals coming directly from the mines, and not one, it is quite safe to say, that is so complete. All coal, from stove size down, passes from the old breaker by means of conveyors 400 feet long to the top of the washery, and then the process of cleaning it by water is begun. The simple principle on which the entire plant is based is that when the broken mass of coal, slate, dirt, etc., as it comes from the mines, is placed in water, the slate and dirt drop to the bottom, while the pure coal rises to the surface, being then removed by scrapers and conveyed through chutes, and the sizes separated. The process of separating the pure coal from the refuse is that almost exactly of skimming milk, except that in the case of the latter the cream rises entirely of its own accord, while in dealing with coal it is necessary to use what are called 'jigs' to shake the broken mass, thus assisting materially and hastening the separation of the pure coal from the refuse. Chestnut and the sizes below are cleaned entirely by machine, but about a dozen boys are employed to go over the pickings of stove coal. The thoroughness with which the cleaning is done is well evidenced by the fact that coal from the washery containing more than a half per cent. of slate or bone will not pass inspection. So far as dirt is concerned, there is really none in the coal after it passes through the washer, and it can be handled when wet without soiling the hands. The entire washing plant is the product of the ingenuity of Lehigh Valley officials. It was in some respects an experiment, but it is one that has proven wonderfully successful. It enables the Exeter colliery to turn out cleaner coal than can possibly be done with the old breaker system."

From the foregoing, some idea can be formed of the amount of coal consumed in furnishing the steam-power required in our great transportation systems and the long list of busy mills and factories. It is hardly possible to conceive the resultant loss should any continued obstacle prevent the regular flow of the great black stream of coal from the mines to the busy engines. It is the life-stream of our country.

CHAPTER XXVII.

THE BLAST FURNACE.

In a preceding chapter I mentioned the letter written by the Pennsylvania Society for the Promotion of Internal Improvements in the Commonwealth to their agent, William Strickland, in Europe. The letter is dated at Philadelphia, March 18, 1825. In addition to the extract quoted regarding the purchase of a model locomotive, is the following with reference to the manufacture of iron in the United States:

"No improvements have been made here in it within the last thirty years, *and the use of bituminous and anthracite coal in our furnaces is entirely unknown.* Attempts of the most costly kind have been made to use the coal of the western part of our State in the production of iron. Furnaces have been constructed according to the plan *said* to be adopted in Wales and elsewhere; persons claiming experience in the business have been employed; but all has been unsuccessful."

When we reflect on the millions of tons of coal, both anthracite and bituminous, now being used every year by the furnaces in our country, it seems hardly credible that this should have been written so recently as 1825. It is even more remarkable that coal was not used in iron furnaces in this country until about 1840. Prior to that time charcoal was the only fuel used in the manufacture of iron. The enormous consumption of coal in our furnaces, forges, and rolling mills was developed, therefore, in a period extending over less than sixty years. Mr. Swank says:

"The line which separates the charcoal era of our iron history from the era which succeeded it, and which may be said to still continue, is marked by the almost simultaneous introduction of anthracite and bituminous coal in the manufacture of pig iron. This innovation at once caused a revolution in the whole iron industry of the country. Facilities for the manufacture of iron were increased; districts which had been partly closed, because of a scarcity of timber for the supply of charcoal, were now fully opened to it; and the cheapening of prices, which was made possible by the increased production and the increased competition, served to stimulate consumption. A notable result of the introduction of mineral fuel was that, while it restricted the production of charcoal pig iron in the States which, like Pennsylvania, possessed the new fuel, it did not injuriously affect the production of charcoal pig iron in other States. Some of these States, notably Michigan, which scarcely possessed an iron industry of any kind in 1840, now manufacture large quantities of charcoal pig iron. The country at large now annually makes more charcoal pig iron than it did in 1840 or in any preceding year. Our production of charcoal pig iron in 1890 was the largest in our history. The introduction of mineral fuel did not, therefore, destroy our charcoal-iron industry, but simply added to our resources for the production of iron. This introduction, however, worked such radical changes in our iron industry, and so enlarged the theatre of this industry, that we are amply justified in referring to it as a revolution and as one which ended the distinctive charcoal era.

"Of the two forms of universal fuel,—anthracite and bituminous coal,—anthracite was the first to be largely used in American blast furnaces, and for many years after its adaptability to the smelting of iron ore was established it was in greater demand for this purpose than bituminous coal, coked or uncoked. In recent years the relative popularity of these two fuels for blast-furnace use has been exactly reversed. The natural difficulties in the way of the successful introduction of anthracite coal in our blast furnaces were increased by the fact that up to that time, when we commenced our experiments in its use, no other country had succeeded in using it as a furnace fuel. We had, therefore, no other guide in its use than our own unaided intelligence."

Walter R. Johnson, writing in 1841, says: "A few years only have elapsed since the introduction of anthracite into extensive use for domestic purposes. A still shorter period has passed since it was held to be a mooted point whether or not the combustible could be used for generating steam, and even after numerous stationary engines, particularly in Philadelphia and its immediate neighborhood, had been using this fuel for several years it was regarded by some as doubtful whether, in steamboats and locomotive engines, it could be substituted for wood. The making of iron with coke, so long practised in England, Scotland, and Wales, as well as on the continent of Europe, *can hardly be said to have yet come into practice in this country*. A number of attempts have, it is true, been made to introduce this important branch of manufacture, and, as was very natural, the State of Pennsylvania, abounding throughout a vast portion of her territory with bituminous coal, in immediate contiguity with beds of iron ore and limestone, has been the scene of most of those attempts."

In 1836 the Pennsylvania Legislature passed an act "for the encouragement of the manufacture of iron by mineral fuel," and in the same year F. H.

Olyphant, of Fayette County, sent to the Franklin Institute samples of iron made with coke. During the years 1835–36 furnaces were erected at Karthaus and Farrandsville, on the west branch of the Susquehanna River, for the manufacture of iron by coke, but both were unsuccessful. In 1839 a coke furnace was in operation at Lonaconing, in Maryland, making "ten tons of pig iron daily, and burning the coke from fifty tons of coal." Near Frostburg were "two large furnaces on the Welsh plan" for using coke or bituminous coal.

"In contrast with this slow progress," says Mr. Johnson, "and languishing state of the coke establishments, we find that within little more than three years the anthracite furnaces have commanded the attention of many enterprising parties, and already not less than *eleven or twelve* have, in Pennsylvania, been devoted to the prosecution of this manufacture."

One of the earliest attempts to use anthracite for smelting iron was made at Mauch Chunk, Pennsylvania, in 1819, by the Lehigh Coal and Navigation Company, but was abandoned.

The "eleven or twelve" anthracite furnaces above referred to were located at Mauch Chunk, Pottsville, Roaring Creek, Phœnixville, Catasauqua, Danville, and Shamokin, in Pennsylvania.

There was also one furnace in operation at Stanhope, New Jersey.

At Catasauqua was Crane Furnace No. 1, belonging to the Crane Iron Works.

"The *stock* at this furnace is very expeditiously elevated from the level of the base of the stack by means of water pumped up by the blast wheel into a cistern near the tunnel head, and which is thence allowed to flow alternately into two boxes of suitable dimensions, suspended by a chain passing over a pulley in such a manner that the descent of one box filled with water, and bearing on its cover the empty barrows for stock, elevates the other box, now emptied of water, but carrying up the barrows, loaded with ore, coal, and limestone."

The cost of Beaver Meadow anthracite coal, delivered to the furnace at Stanhope, New Jersey, was $4.00 to $4.50 per ton.

In the year 1898 the State of Pennsylvania had 72 anthracite furnaces, New York had 12, and New Jersey had 10, a total of 94, with an annual capacity of 3,009,487 tons of pig iron.

Remarkable as the growth has been of the number of furnaces using anthracite coal, the number of bituminous furnaces shows a much greater increase. The beginning was even more discouraging than that of the anthracite furnace men. In 1849, Overman, writing of coke furnaces in the

United States, said, "As there is but little prospect of an addition to the number of coke furnaces which now exist, we shall devote but a limited space to this subject." In 1835 the Franklin Institute had offered a gold medal "to the person who shall manufacture in the United States the greatest quantity of iron from the ore during the year, using no other fuel than bituminous coal or coke, *the quantity to be not less than twenty tons.*"

The first bituminous furnace built in the United States was at Bear Creek, in Armstrong County, Pennsylvania. This was in 1819, and was not successful. After two or three tons of coke iron had been made the furnace chilled. It was then put in operation with charcoal.

In 1834 a Senate committee of the State of Pennsylvania filed their report, stating that "the coking process is now understood, and our bituminous coal is quite as susceptible of this operation, and produces as good coke, as that of Great Britain. It is now used to a considerable extent by our iron manufacturers in Centre County and elsewhere."

In 1835 a good quality of iron was made in the Mary Ann furnace in Huntingdon County, Pennsylvania, with coke made from Broad Top coal. This was probably the first successful effort made in this country to use bituminous coal in blast furnaces.

"But," says Mr. Swank, "the use of coke did not come rapidly into favor, and many experiments with it were attended with loss. It was not until after 1850 that its use began to exert an appreciable influence upon the manufacture of pig iron. In 1849 there was not one coke furnace in blast in Pennsylvania. Overman stated in his book that year that he knew of no coke furnaces in this country which were then in operation. In 1856 there were twenty-one furnaces in Pennsylvania and three in Maryland which were using coke or were adapted to its use, and their total production in that year was 44,481 gross tons of pig iron. After 1856 the use of this fuel in the blast furnace increased in Pennsylvania, and was extended to other States, but it was not until after 1865 that its use for this purpose increased rapidly. Not more than 100,000 gross tons of coke were consumed in the production of pig iron in this country in that year. A tremendous stride was taken in the next fifteen years, however, the quantity of coke consumed in the blast furnaces of the United States in the census year 1880 having been 2,128,255 net tons. In the census year 1890 the consumption of coke for this purpose was about 10,000,000 net tons!"

In 1898 there were 247 blast furnaces in this country using bituminous coal and coke. These were distributed over 17 States: 78 were in Pennsylvania, 47 in Ohio, 37 in Alabama, 23 in Virginia, 17 in Illinois, 12 in Tennessee, 6 in Kentucky, 5 in Maryland, 4 each in West Virginia and Wisconsin, 3 each in New York, Missouri, and Colorado, 2 each in North Carolina and Georgia, and 1 in Minnesota. The annual capacity of these furnaces was 15,114,700 gross tons of pig iron, or over five times as much as the combined product of all the anthracite furnaces in the United States.

CHAPTER XXVIII.

COMBUSTION.

The substances found in coal by combining with the oxygen of the air produce the phenomenon of combustion. I have explained the nature of the principal costituents of coal—the organic matter, carbon, and volatile gases, hydrogen, oxygen, and nitrogen, and the inorganic matter—ashes.

Carbon gives the *heat,* and the hydrogen in the volatile matter the *flame.* The more carbon there is in coal the more continuous will be the heat, and inversely the less inflammable it will be. And the more hydrogen there is in the volatile matter the coal contains the more inflammable it will be, with less heating power. This is illustrated in the combustion of wood and of anthracite coal. Wood contains 6 per cent. of hydrogen and but 50 per cent. of carbon; it is very inflammable, but has little heating power; while anthracite, with 90 per cent. of carbon and only 3 per cent. of hydrogen, has the greatest heating power of all coals and is the least inflammable. We have this description of familiar combustion from William H. Barr:

"When a piece of rich bituminous coal is thrown upon a brisk open fire, a parlor-grate for example, it will be observed that physical changes in this piece of coal rapidly occur. First, a disengaging of small particles of coal, which are often projected from the larger piece with some violence, then a swelling or puffing out of the exterior surfaces of the coal; jets of smoke issuing here and there, proving themselves to be rich in inflammable gases, for soon they burst into a flame, often white and intensely brilliant near the coal, fading into a brownish-yellow flame, terminating in smoke. Presently the piece of coal will show indications of cleavage, and may split itself into two or more parts. Sometimes this will go on until the whole lump disintegrates or goes to pieces; at other times it will continue to swell, expanding to much more than its original volume, giving off its gases, and a caking process is undergone until the whole mass is apparently fixed together, after which, the volatile portions of the coal having been expelled and burned, the remaining portion assumes the general incandescent state of the body of the fuel in the grate, disappearing little by little through the action of some unseen agency until it yields up all its combustible substances, and ashes alone remain to mark the completeness of the change."

When coal is heated to the point of ignition the oxygen unites with the carbon and hydrogen in the coal and the result is combustion. This is nothing more than a chemical change, producing energy in the form of heat. A piece of iron slowly rusting is undergoing a similar change. In a recent paper read before the Civil Engineers' Club the author, Dr. C. F. Mabury, says:

"In considering the various forms of combustion we must bear in mind the relations of the ordinary combustibles and the supporter of combustion. Ordinary combustibles include coal, wood, charcoal, natural gas, oil, coke, and turf. The supporter of combustion is the oxygen of the atmosphere. The union of other elements, however, in such a way as to unite and develop energy, may be looked upon as a phase of combustion.

"The carbon compounds are the least expensive combustibles, and oxygen of the air the cheapest supporter of combustion. If hydrogen and chlorine be brought together under suitable conditions, there will be a great liberation of heat energy; but these substances are too costly to be used in ordinary heating operations. The greatest energy and efficiency in combustion is obtained by the union of gases, because the molecules have perfect freedom of motion, and the molecular proportions of the union may be more readily controlled.

"In burning two volumes of hydrogen and one volume of oxygen, we have the greatest amount of heat that can be developed in ordinary combustion, equivalent to 34,452 kilogram heat units. The molecules of these gases are free to move, and require no expenditure of energy to bring them to the point of ignition, except the small amount of heat due to their specific heats. The efficiency of natural gas as a combustible is due to the same properties, and to the fact that it is composed largely of marsh gas. The hydrogen burns first and maintains the temperature necessary for complete combustion of the carbon. The products are water and carbonic dioxide, and the calorific power generated in its combustion is 11,063 kilogram heat units. Wood is the least efficient of the combustibles, on account of the great amount of water it contains that must be converted into steam.

"Coal, as we know, is composed of carbon, hydro-carbons, sulphur, nitrogen, oxygen, and mineral constituents. When marsh gas burns, the hydrogen burns first; then what oxygen remains is taken by the carbon. The same is true in combustion of coal. Soft coal consists to a large extent of volatile matter. All of the hydrogen in the hydro-carbons of the volatile portions burns first; then, if there is a sufficient amount of oxygen, the carbon combined with the hydro-carbons burns; and finally the fixed carbon. In the combustion of coal, carbon forms first carbonic oxide; then, by further union with oxygen, carbonic dioxide, the ultimate product of combustion. The conversion of carbon into carbonic oxide is attended by the evolution of 5680 kilogram heat units. From carbonic oxide to carbonic dioxide the heat evolved is equivalent to 2400 heat units. Dry wood when burned evolves on an average 3650 heat units, and bituminous coal an average of 7500 heat units. Anthracite coal evolves considerable more heat energy. There is greater difficulty in obtaining the same efficiency from the bituminous coal than from anthracite coal, because of the way in which it burns, as above mentioned. It contains such a large proportion of the volatile hydro-carbons that the distillation of those substances must be controlled within the area of combustion. If bituminous coal be fired chiefly from below, so that the air necessary for combustion comes through the grate bars, that portion of the coal on the grate bars will be perfectly consumed; but the portion above, being only partially heated, will be subject to a process of destructive distillation. The volatile portion will be decomposed and soot will escape. Soot, when once formed, cannot be burned economically."

The cause of the spontaneous combustion of coal is not yet fully understood. It has been the subject of much speculation as well as of careful scientific inquiry. It has been ascertained by observation that "the tendency of coals to spontaneous combustion is increased by a moderate heat." Graham, in 1852, gave the following examples:

"In one case coal had taken fire by being heaped for a length of time against a heated wall, the temperature of which could be easily borne by the hand; in another case coal ignited spontaneously after remaining for a few days upon stone flags covering a flue of which the temperature never rose beyond 150° Fahrenheit. Coals thrown over a steam-pipe ignited. Coals piled against a brick wall two feet thick, of which the temperature did not exceed 120° to 140° Fahrenheit, became ignited. Neither did it appear to matter whether the coal was Lancashire and sulphurous or Wallsend and bituminous."

Charles W. Vincent writes: "Coals conveyed through the tropics—in vessel cargoes—are certainly in this state of danger. When coal takes fire spontaneously it is invariably in the centre of the heap of small coal at the foot of the hatchway or in the middle of the cargo, in this respect resembling the spontaneous combustion of haystacks, oily waste, etc., and from hence it may be inferred that the increments of heat which cumulate in vivid combustion are very small. Coal in small quantity, and in a cool place, never ignites spontaneously."

It is generally supposed that heaped-up iron pyrites in shale or a culm bank, when wetted, cause the combustion of the pile. This has often been used as an argument against the shipment of "brassy" coal,—*i.e.*, coal containing these pyrites. "But supposing this were so, and that the pyrites were disseminated through a part of the cargo in sufficient quantity to cause evolution of heat when wetted, this would account for but a small number of the cases of spontaneous combustion of coal, *since by far the larger number happen with coal free from pyrites.*"

Professor Medem gives as his opinion: "Ignition results from the oxidation of the iron pyrites contained in the coal when exposed to the action of oxygen and moisture. The danger is greater the finer the division of the coal, and coal stacked above-ground is particularly liable. Attempts made to reduce the danger by ventilating the stacks have failed in this case also, on account of the increased amount of oxygen thereby introduced into the interior of the mass, and accordingly the coal is stacked as tightly as possible to exclude air."

It would appear then that the practice of ventilating the ship's coal bunkers is a most dangerous one, and only increases the liability of spontaneous combustion. Liebig warned ship owners against this practice in 1866. "Since that date 97 coal-laden vessels have been destroyed and the lives of some 2000 seamen sacrificed through spontaneous ignition of the cargo."

This danger to coal-ships is much greater on long voyages and in tropical countries than to coasters or vessels making a short cruise.

In 1890, F. W. Rademacher offered a prize for the best method of preventing the spontaneous ignition of coal in vessels at sea, but without any very successful results. Martin Stange, of Vegesack, proposed that bottles containing liquid carbonic acid, fitted with stoppers of Lipowitz metal —an alloy fusing at 60° Centigrade—should be embedded in the coal; the gas would be liberated on the fusion of the stoppers when the temperature became high enough through spontaneous ignition, and would drive out all the oxygen present in the stored coal and extinguish the fire.

Kraus, in 1894, discussed the subject from a practical stand-point, and pointed out that the risk of coal explosions on shipboard is limited to the period directly following loading, and can be combated the same way as in the pit, by keeping the coal dry, ventilating the hatches by opening them in dry weather, and avoiding the use of naked lights in the hold.

For the suppression of fires due to spontaneous ignition he recommends the use of hollow supports for the deck-beams, connected below the storage of coal with a properly-distributed system of pipes, particularly under the loading hatchways, where the greatest amount of small coal is to be found, as this is the chief seat of danger. The hollow supports serve—as in war ships—in the first place as openings for conveniently ascertaining the temperature of the coal. If this is found to have appreciably risen, it indicates that the chemical changes are going on. In such event the next step is to cover the surface of the coal at the seat of danger with a dressed tarpaulin to keep out the air, and to connect the opening in the centre of this cloth with an exhaust fan by means of a pipe. At the same time the hollow deck-beam supports are connected to an air-pump delivering carbonic acid from a reservoir. Both pump and fan being set to work simultaneously, the air and gases are removed from the coal and replaced by carbonic acid, which will prevent further ignition. When the exhaust air is found to contain carbonic acid it may be safely assumed that the coal is thoroughly saturated with the gas; further proof will be afforded by reduced temperature. Kraus further states that before the hatches are put on again the air in the hold should be carefully tested by lowering a safety-lamp, and if the latter is extinguished the carbonic acid thus indicated should be drawn out and replaced by air. The necessary installation for carrying out this process is inexpensive, and any liquid carbonic acid unused can be readily sold at the port of debarkation should a different return freight be carried. Another writer states that "spontaneous combustion is due to the absorption of the oxygen in the air. All kinds of coal, after being cut or broken, begin to absorb oxygen, the amount varying according to the quality of the coal. The absorption of the oxygen raises the temperature of the coal, and the temperature increases in proportion to the rate at which the oxygen is taken in. Although the absorption of oxygen does not raise the temperature sufficiently high to cause combustion, the oxygen itself becomes chemically active; and when such action is going on in the centre of a pile of coal a sufficient quantity of air may be supplied, which, combining with the hydrogen and carbon in the coal, will cause spontaneous combustion. The pyrites in the coal also play an important part in promoting combustion. The chemical changes which the pyrites undergo, especially if there is a large percentage of that substance present, in some instances liberate sulphur, and, as the temperature necessary to ignite sulphur is only 482° Fahrenheit, while in the case of cannel (bituminous) coal—which ignites at the lowest temperature among the several kinds—698° Fahrenheit are required, it will be seen that, with the chemical changes referred to, the actual temperature of ignition is lowered over 200 degrees. Pyrites also promote spontaneous combustion through the tendency of the coal to split up into small pieces, due to expansion from oxidation, thus exposing fresh surfaces with a consequent increased absorption of oxygen."

The majority of authorities among practical and scientific men agree that the chief source of danger from spontaneous combustion is contained in the excess of sulphur which may be in the coal, and in low-grade coals containing a large percentage of slate. This is not always the case, as many thoroughly high-grade coals have ignited in the same way.

The cause of spontaneous combustion and the remedy is still a matter of considerable doubt and uncertainty. The effect is lamentably apparent in the numerous losses of large stacks or piles of coal, the destruction of many vessels, and, worse than all, the loss of precious human lives.

CHAPTER XXIX.

MECHANICAL PREPARATION.

VARIOUS methods have been tried for preparing coal mechanically in order to facilitate combustion, or to more economically extract all the heat units from low-grade coals, which as "run of mine" would prove refractory in a furnace.

The most common in use in this country is simply by screening and washing, but more elaborate contrivances have been devised by which the volatile gases are separated from the coal, and are then used for all purposes of combustion at the will of the consumer. This latter process is the perfection of utility and convenience, and it seems incredible in this age that any intelligent householder will permit a gas-works in full operation in his cellar—with all the dirt and annoyance of heaving in tons of crude coal, and the greater dirt of heaving out tons of ashes, together with the additional labor of attending to the manufacturing at all times and seasons—when he can have the gas delivered to any part of his house, always on tap and ready at a moment's notice to give its full and perfect combustion with its accompanying heat.

Let us take for example the familiar hot-air furnace of the pattern in general use for burning anthracite coal in our cellars. What is it but a very crude and defective apparatus for manufacturing a small amount of gas which we ought to buy more cheaply from a large central company, organized to produce gas at wholesale, and equipped with all modern mechanical contrivances for doing the work better and more economically than we can individually? For bear in mind that in every kind of furnace using any variety of fuel it is the gas only that we burn, and from the gas alone we obtain the heat; the structure or inorganic matter of the coal remains unconsumed, and must be thrown away as ashes. Let it be understood, then, that we have a small and very inefficient gas-works in our cellar, and, the day being chilly, we proceed to start up our gas-works in order to produce the necessary heat and warmth.

We know by experience that anthracite coal will not ignite except at a high temperature; we begin, therefore, to produce this temperature by igniting a large quantity of highly combustible materials—paper, light pine shavings, or wood. The chimney is cold and damp, our draughts and apparatus more or less defective, and combustion is slow. The results are imperfect, and a dense smoke permeates every corner of the furnace, and, escaping through the many cracks and openings, finds its way through the house. Presently the temperature increases, and, the draughts becoming operative, the fire of wood burns briskly, and the anthracite is put on. Now we are making gas. The doors are closed, the apparatus adjusted, and the temperature is rising. In an hour, probably more, combustion has proceeded rapidly, and the gas has been produced,—some of it burning and producing heat, and more or less escaping through the joints and connections of the apparatus, and even through the porous iron itself to our rooms above. We are consuming now from ten to fifteen pounds of anthracite per hour for every square foot of grate surface. The house is getting hot—too hot. Another adjustment of the apparatus, and most of the products of combustion are forced out of the chimney, and the consumption of anthracite goes merrily on. By evening, the house being sufficiently warmed and the gas-works in our cellar not needed, the order is issued to put the fire out. But right here is another difficulty. Anthracite coal, once thoroughly ignited, is not easy to quench. We might turn the hose on it, or a couple of buckets of water, but the result would probably be an explosion wrecking the furnace. There is nothing to do but wait until the coal has burned to ashes—a condition requiring nearly another day to complete.

To "take the chill off the air" that frosty morning, it has been necessary to run our gas-works for thirty-six hours. It is now in order to clean out about ten per cent. of ashes, and have the apparatus ready for the next fall in the thermometer.

The same process is performed in our kitchen every morning in summer, and the same wasteful production of heat is made for the purpose of boiling a kettle of water or broiling a beefsteak. If the fire is not kindled afresh each morning, it is kept burning all day and all night in order to make the few units of heat necessary for culinary uses during a period of time which is but a fractional part of the day.

From the foregoing homely illustration of the use of crude fuels we deduce the following advantages to be gained in the use of fuel gas:

1. We avoid having a gas-works in our kitchens or cellars, with all the accompanying dirt and handling of heavy material.

2. The gas only is burned, without the trouble and annoyance of making it.

3. No wood or kindling is required; no smoke or escaping gases.

4. The required heat to effect the object desired

only is used,—either to boil a kettle of water or to heat the house.

5. The combustion is under perfect control; a fire can be made instantly and stopped at once.

The amount of gas which can be obtained from a ton of coal by the Lowe (water) process is equal to a volume of 50,000 feet. With this kind of fuel the question of economy is manifestly all in favor of gaseous fuels.

The problem of the efficient utilization of very small coal has attracted a great deal of attention for many years.

The following on the combustion of powdered coal is from the *American Manufacturer:* "A considerable proportion of the fine slack made in the getting of coal is left underground, but large quantities are made in the operations of screening and generally handling the coal on the surface, and it has to be sold at a price far below its true calorific value on account of the difficulties that appertain to its use. An invention that bids fair to overcome many of these drawbacks has recently been introduced in the form of the Wegener method of firing boilers with powdered coal. It is not pretended that the use of finely powdered coal is altogether new. Many experimenters have been busy for the last quarter of a century in this direction, but none seem to have attained the same measure of success. As long ago as 1873, Mr. T. R. Crampton described before the Iron and Steel Institute his endeavors to use finely divided coal in puddling and other furnaces. At the time he seems to have been fairly successful, but for some reason his process never came into general use. Of recent years more attention has been paid to the subject in Germany, and the first automatic arrangement was devised by Wegener in 1892. Since that day two other systems have been introduced by Friedeburg and Schwartzkopf.

"The Wegener apparatus is exceedingly simple. Coal ground to pass through a sieve of sixty meshes to the linear inch is tipped into the hopper at the top, whence it falls upon a grating by which it is retained. This grating is subject to a continual knocking action, which keeps the coal dust falling through it in a cloud. The knocking is effected by a wheel with vanes in it. The air enters here under the influence of the chimney draught, and passing through the wheel puts it in rotation. The shaft of the wheel is continued upwards to the grating, where it operates the knocker 151 to 250 times a minute. The strength of the knock can be regulated by means of a screw and a spring, and thus the amount of coal passing can be varied between very wide limits. The coal dust in falling meets the rising air current, and both are diverted through the side pipe into the furnace. The air can be regulated by raising and lowering the end of the air-pipe, which serves as a damper. A second pipe provides for the admission of a supplementary air current when required. The interior of the furnace is lined with fire-brick for a length of 10 or 12 feet, and has, in addition, two fire-brick bridges. There is no grate and there are no fire-doors, the combustion being watched through peep-holes.

"Several of these furnaces have been working in Berlin for a year or so, and last spring Mr. Donkin made a test there of a Cornish boiler, fired first by hand, and, a few days later, by the same coal in a powdered condition. The boiler was 5 feet 7 inches in diameter by 28 feet 4 inches long, with one flue 2 feet 7½ inches in diameter. The total heating surface was 500 square feet, and the grate surface 13.8 square feet. The first experiment was made with very small English flaming coal (about ⅛-inch pieces). The fire-bars were ¾-inch wide, with $\frac{5}{16}$-inch air spaces, and were not well suited for the kind of fuel under test. The results show that the dry powdered coal evaporated from and at 212 degrees 9.11 pounds of water per pound of dry coal, as against 6.48 pounds for the hand stoking. The result is, however, so poor—owing to the condition of the grate

—that it cannot be taken as a proper basis of comparison. Nevertheless the trials show that the Wegener system can give economical results, especially with small and cheap coal. The cost of grinding is said to be about 25 cents per ton.

"The system is not only applicable to firing stationary boilers, but it can be used for marine and locomotive boilers and for metallurgical furnaces. For these purposes it is in some respects comparable to gas and oil firing in that the regulation of the temperature is almost equally simple. At the same time the transport of the coal dust from the bunkers could be made much simpler than that of coal. According to experiments made, the economy of this system over hand stoking is as high as 20 per cent. or more, depending upon the kind of a boiler and fuel, and on the rate of consumption. The economy is due to the better combustion or higher percentage of carbonic anhydride in the furnace gases. No cold air enters, as there are no fire-doors to open; each particle of coal is surrounded by air, giving excellent conditions for chemical combustion, and there is no smoke."

With reference to powdered coal mention can properly be made here of a plan recently suggested for crushing all coal to a powder at the mines, and then after mixing it in water to send it through pipe-lines from the mines to destination. Coal is not much heavier than water, and could readily be carried in this manner.

On arrival the water could be evaporated and the coal used in its powdered state, or it could be pressed into briquettes of any desired size or shape by hydraulic pressure.

Such a plan if carried out would revolutionize the transportation of coal, but at the present writing it stands merely as a suggestion with very scant prospects of acceptance.

The problem for the American inventors to consider is the production of electricity direct from coal without the expensive intervention of the steam-engine. Several inventions have already been made, but none so far can be called commercially successful.

The same amount of ingenuity is being exhibited in the numerous devices for the prevention of smoke during combustion. The following description of Colonel Dulier's system is from the *American Gas-Light Journal:*

"The serious difficulty with nearly if not quite all the appliances which have been devised for consuming smoke is that they do not pay. The heating capacity of smoke is so little that it is cheaper to waste the smoke than to utilize the small amount of potential heat there is in it; besides this, some portions of the smoke are incombustible. Colonel Dulier has devised a system of smoke prevention, by which the smoke after leaving the furnace is mixed with steam in an ascending flue, and then in a descending flue is met by a very fine spray of cold water. The result is that the larger part of its constituents are dissolved or precipitated and escape with the water into the drains from a tank at the bottom of the descending flue. Any residue passes out with a certain amount of steam from a chimney fixed in the tank. A rough proof of the efficacy of the arrangement is afforded by the fact that a piece of white cloth may be held for some minutes over the top of this chimney without becoming apparently blackened.

"Colonel Dulier's apparatus is in use at the City Saw-Mills, Glasgow, and at Messrs. Merryweather's factory at Greenwich, and is being fitted to the Opera in Paris. At Messrs. Merryweather's the smoke from 11 forges is collected in one main flue, and after being mixed with steam is subjected to the action of three water-jets consuming 100 gallons of water an hour. The system is here found so satisfactory that the rest of the forges are shortly to be connected, and it is considered that the same amount of water will be sufficient to treat the smoke from them also. From observations made by the Public Analyst of Glasgow at the saw-mills, it appears that the apparatus there removes over 90 per cent. of the solid matter of the smoke and more than half the sulphurous acid. It does not affect the draught in the chimney, any loss caused by the bends of the flues being compensated by the effects of the jet of steam which damps the smoke. In Glasgow this jet is at a pressure of from 80 to 100 pounds per square inch, but, though a fairly high pressure both for steam and water jets seems to be advantageous, yet it is not necessary.

"The apparatus has been fitted to a stack of chimneys in a house in Belgravia, and has worked satisfactorily, using the water from the mains and the steam given off by an ordinary high-pressure hot-water boiler. It is even said to have resulted in a reduction in the amount of coal burnt. There is an incidental advantage connected with it which may commend itself to people who are solicitous about sanitation. The water which has been used in the flue contains a quantity of sulphurous acid, and is, therefore, a disinfectant of considerable power. The cost of construction ought not to be very great, since the flues are only large steel tubes. But if the apparatus fulfils all that is claimed for it, manufacturers might find themselves recouped for their outlay by being able to burn an inferior and cheaper coal without producing an improper amount of smoke."

CHAPTER XXX.

GAS COALS.

Many bituminous coals are called by the trade "gas coals." I have given average or typical analyses of the semi-bituminous and anthracite coals of Pennsylvania—that are used and valued chiefly for steaming purposes—in a preceding chapter. By comparing the following analysis of a high-grade bituminous coal mined at Herminie, in Westmoreland County, Pennsylvania, with the foregoing analyses, the reader can intelligently compare the different proportions of the various kinds of coal, and easily determine what constitutes a "gas coal."

For example, an analysis of the Westmoreland County coal would yield about the following proportions:

	Per cent.
Fixed carbon	59.00
Volatile matter—hydrogen, oxygen, nitrogen	35.40
Moisture	1.00
Sulphur	.60
Ash	4.00
	100.00

By comparison we note the following:

First.—A very high percentage of volatile matter, consisting of highly combustible gases.

Second.—A comparatively low percentage of fixed carbon or organic matter.

Third.—A similar percentage in sulphur, ash, and moisture as is contained in the semi-bituminous and anthracite analyses.

The difference in the coals, therefore, is contained in the first and second comparisons,—*i.e.*, in the fixed carbon and volatile matter, and indicates that bituminous coal will ignite readily, and that combustion would be free and more rapid than in the other two coals. Also, that the excess of hydrogen in this kind of coal would render it particularly suitable for the production of carburetted hydrogen, or, as it is commonly called, "gas." Hence, the term now commonly applied to it of "gas coal."

This gas is not peculiar to bituminous coal. In an old edition (1818) of "Gas Light," by Frederick Accum, I find: "Carburetted hydrogen gas is also given out very abundantly by all kinds of vegetable matter, when subjected to a scorching heat sufficient to decompose it. When heated in closed vessels, much more gas is obtained than when burnt in the open air. If moistened charcoal be put into an earthen retort and heat be applied till the retort becomes ignited, gas will be evolved, consisting partly of carbonic acid and partly of carburetted hydrogen.

"A gas of similar properties is obtained by causing steam to pass through a tube filled with red-hot charcoal; by passing spirits of wine or camphor through red-hot tubes; by distilling oils, wood, bones, wax, and tallow, or any animal or vegetable matter whatever." From the same source we learn that "a new art of procuring artificial light, which consists in burning the gaseous fluid obtained by distillation from common pit coal, has of late engaged the attention of the public under the name of 'gas-light,' and that certain individuals had the temerity to organize a company under the name of the 'Gas-light and Coke Company,' to apply this new art of procuring light—by way of experiment—on a large scale in lighting the streets of the metropolis."

The act read as follows:

"An act for granting certain powers and authorities to a company to be incorporated by charter, called the 'Gas Light and Coke Company,' *for making inflammable air* for the lighting of the streets of the metropolis, etc.—Session 1810, 50th Geo. III."

The power and authorities granted to this corporate body were very restricted and moderate:

"The individuals comprising it have no exclusive privilege; their charter does not prevent other persons from entering into competition with them. Their operations are confined to the metropolis, where they are bound to furnish not only a stronger and better light to such streets and parishes as choose to be lighted with gas, but also at a cheaper price than shall be paid for lighting the said streets with oil in the usual manner.

"The corporation is not permitted to traffic in machinery for manufacturing or conveying of gas into private houses; their capital or joint stock is limited to £200,000, and his Majesty has the power of declaring the gas-light charter void if the company fail to fulfil the terms of it."

That some of the old English coal-dealers were not troubled with more conscience than some of our present-time dealers possess is shown in the following:

"In coal-sheds the measure as well as the mixing one kind of coal with another is often scandalous, for the act of Parliament does not take the least notice of the small measures. It is a known fact when a fraudulent dealer orders in a room of coals, for every chaldron of 36 bushels, if he does not send them out at the rate of 42 bushels again he will be dissatisfied with his measure. This is extremely hard upon the lower class of people, who are only able to purchase a peck or half-peck at a time; and let the measure be ever so bad they have no means of redress.''

The following theory of the combustion of gas coals is by the same author:

''Everybody knows that when bituminous coals are burning in our grates a flame more or less luminous issues from them, and that they frequently emit beautiful streams of flame remarkably bright. But besides the flame, which is a peculiar gas in the state of combustion, heat expels from coal an aqueous vapor, loaded with several kinds of ammoniacal salts, a thick viscid fluid resembling tar, and some gases that are not of a combustible nature. The consequence of which is, that the flame of a coal fire is continually wavering and changing, both in shape as well as in brilliance and color, so that what one moment gave a beautiful bright light, in the next, perhaps, is obscured by a stream of thick smoke. But if coals, instead of being suffered to burn in this way, are submitted to distillation in close vessels, all the immediate constituent parts may be collected. The bituminous part is melted out in the form of tar. There is disengaged at the same time a large quantity of an aqueous fluid, contaminated with a portion of oil and various ammoniacal salts. A large quantity of carburetted hydrogen and other inflammable gases make their appearance, and the fixed base of the coal remains behind in the distillatory apparatus in the form of a carbonaceous substance, called coke.''

The principal bed of "gas coal" in the United States is in the country adjacent to Pittsburgh, Pennsylvania, and is described by Mr. Adams as follows: "It is spread over the five southwestern-most counties and exposed to commercial operations in profusion and in all directions by the erosion of the many and noble streams that flow through it. The Allegheny River to the north, Youghiogheny and Monongahela to the south, joining at Pittsburgh to form the mighty Ohio, are lined with coal-mines along their banks, and expose long lines of virgin coal in the more remote regions, awaiting the expansion of the coal production that will necessitate their development. These streams are wide and shallow, and great dams have been built across them to back up the water and to give a floating depth to the coal-laden barges and the steamers that tow them. These dams have been built at varying distances along the Monongahela River from Pittsburgh clear up to the Pennsylvania State line.

"As a basis for the slack-water navigation of its tributary rivers, an immense dam was built at Davis Island, on the Ohio River, a short distance below Pittsburgh. This provides for water up to the first dam of the Monongahela River opposite the city of Pittsburgh. Other dams at varying distances, to the number of seven in all, reach to within a few miles of the West Virginia line. The second dam is located ten miles above the first, near the town of Braddock. The third dam is just below the town of Elizabeth, twelve miles or more above the second. The locations of these dams have been described thus minutely because they have been used to define to a certain degree the limits of the best gas coal. The slack-water area between the different dams is known as a 'pool.' Thus the water between the first and second dam is known as the 'first pool,' and the water between the second and third dam, or say between Braddock and Elizabeth, is known as the 'second pool.' In the latter term a well-known and generally used trade name will be recognized, designating the best grade of gas coal. This has come about because the slack water above the second dam, extending down the Youghiogheny as well as the Monongahela River, lies in the belt of best gas coal."

Up to 1842 the Virginia coal was the principal source of domestic supply in this country, and until 1850 constituted the chief supply to the gas-works of Philadelphia and other American cities.

About six years later the gas coals of western Pennsylvania began to be used in Philadelphia to the practical exclusion of both the foreign and the Virginia coals.

The use of gas as a modern illuminant has become so general in this country that I will merely touch on the improvements which have been made in its production from coal.

The first principle of producing the gas by distillation in a large vessel of fire-clay or metal is still the basis of our present modes of procedure. In this way a ton of good gas coal will yield about 10,000 cubic feet of illuminating gas, but "a vast improvement on this process is obtained by taking the coal used in the first operation, which has now become coke, heating it to incandescence, and forcing steam through the mass. By this means about 30,000 more feet of gas are obtained from the ton of coal, not including such coal as is used for the fires producing the heat. The gas produced by this process in which steam is used is called 'water gas,' since it is the decomposition of the water that releases the hydrogen forming the gas. A vapor made from crude oil is commonly added in small quantities to give greater illuminating power. Carbon when highly heated has so much affinity for oxygen that it will decompose steam in order to combine with the oxygen that forms a part of the steam. This is the principle that makes 'water gas' possible. Either anthracite coal or coke may be used to secure the necessary carbon."

Recently a combination of calcium (lime) and carbon (charcoal) with water has been made to produce a powerfully brilliant light by forming what is known as "acetylene gas."

Thomas Bolas states that "the discovery of acetylene by Berthelot, something like half a century ago, takes us back to the time when investigators of Liebig's school and following were laying the foundations of many modern industries, and it was within what might be called the Liebig period of research that Nohler prepared ' calcium carbide' or 'calcium acetylene' from inorganic materials. By decomposing it with water he produced acetylene together with slacked lime."

The recent production of calcium carbide on a large scale in America becomes a step in progress calculated to immediately fructify. A danger to be guarded against in the use of acetylene is its tendency to form dangerously explosive compounds with copper, silver, gold, mercury, and several other metals. It is also explosive if too much air is added, and accidents have happened in its use through neglect or ignorance of this fact.

It is hoped that the cost of calcium carbide can be reduced to about $15 per ton by using limestone (lime) and coal dust (carbon). Experiments have been made on an extensive scale with this object in view. At present the commercial value of calcium carbide is about $160 per ton, and so far the parties interested in its manufacture have accomplished very little in the way of reducing these figures.

The acetylene flame is very white and luminous, and when burned at the usual gas-light rate of six feet an hour emits a light twelve times more brilliant than enriched water gas.

CHAPTER XXXI.

COKE.

Everybody knows what charcoal is,—the carbonization of wood and its product in the shape of common charcoal is familiar to all. The same process applied to certain kinds of bituminous coal produces "coke," which is not so generally known. As early as 2000 years ago coke was an article of commerce in the Chinese province of Hunan, while, further, the Chinese were making briquettes from clay and coal-dust thousands of years ago, when the use of coal in Europe as a heating agent was practically unknown.

A patent was issued as early as 1557 in Germany for a process that was called the "desulphurizing of coal." In 1590 a license was issued for cleaning coal and freeing it from its disagreeable smell, and further patents followed in 1620 and 1627 for smelting iron with coke, and rendering coal as useful and agreeable as charcoal for domestic purposes. Again, a further patent was issued in 1633 to several parties for "charking coal" and smelting iron.

Dr. Percy says: "The date of the first application of coke as fuel does not appear to have been ascertained. When charcoal became dear, especially on account of the increased consumption of it in iron-works, and coal was coming into general use, attempts would naturally be made to produce from the latter a substance which might be substituted with advantage for the former; and, obviously, the first experiment would be to subject coal to a process similar to that of charcoal-burning, when coke would be produced, and soon be found valuable as fuel for various purposes.

"Until comparatively recent times coke was always made by burning coal in piles, technically designated 'fires,' and even at the present day coking in this manner is extensively practised. It is stated that in March, 1651, Jeremy Buck, by a special act of Parliament, obtained a patent for making iron with stone coal, pit coal, or sea coal without 'charking.' Hence it may be inferred that the process of coking was known and practised befort that date. The verb 'chark' means 'to burn to a black cinder,' whereas the meaning of 'char' is defined to be 'to burn wood to a black cinder.'

"In Plot's 'History of Staffordshire,' published in 1686, it is recorded that coal was charred in exactly the same manner as wood, and that the coal thus prepared was called 'coak,' which was capable of producing almost as strong a heat as charcoal itself. It was used for drying malt, and could generally be employed as a substitute for charcoal, except for 'melting, fining, and refining of iron, which,' says Plot, 'it cannot be brought to do, though attempted by the most skilful and curious artists.' Swedenborg, writing in 1734, informs us that, in certain districts in England, coke was employed in the smelting of iron, and that cinders and coke were synonymous. In 1769, Jars announced the fact that coke was made in England, not only in piles, but also in a closed furnace, of which, however, he did not describe the construction. The ironmasters of Liege, a short time afterwards, adopted with success that system of coking. At about the same time, according to Horne, coking in ovens was carried on in the villages around London, the coke being prepared for the use of malsters and for some other purposes. He has given the following description of the process: 'These ovens being from time to time charged with a proper quantity of coals, they set them on fire. Near the front or opening of these ovens the chimneys are placed, at which outlets, when the coals become sufficiently ignited, the flames which play around the interior parts of the oven make their exit, carrying along with them a very considerable part of crude sulphur. The workmen employed at these ovens, when they imagine the coals sufficiently burnt, draw them out with an iron rake upon the ground before the oven, where they endeavor to stifle the yet remaining part of the sulphur by quenching them with a deluge of water. Thus they go on, charging, discharging, and suffocating, till they have completed their intended quantity.' An experimental coke oven, on a plan proposed by Horne, was erected in Staffordshire, and, it is stated, with a successful result. The details of the plan are not given. It appears, however, that the oven consisted of a closed arched chamber, and that on trial it was found to be desirable to have some outlet 'in the top of the crown' for the escape of vapor, in order to prevent the blowing up of the oven. In 1781, according to Bishop Watson, the application of coke to the smelting of iron had become general in England, and coke ovens were in operation at Newcastle-on-Tyne, and even at Cambridge, where the coke was used for drying malt."

The constituent parts of coke are principally carbon and the inorganic matter of the coal,—ash.

A typical analysis of coke would be as follows:

	Per cent.
Fixed carbon	89.50
Moisture	.30
Volatile matter—hydrogen, oxygen, nitrogen	.40
Sulphur	.80
Ash	9.00
	100.00

An examination of this analysis and comparison with the coal analyses previously given show the position of coke as a fuel. The excess of carbon ranks it as capable of great heating power, and the small amount of combustible gases as slow to ignite and free from smoke during combustion. The "impurities," as they are called, in coke are contained in the sulphur and phosphorus which a sample may contain. The ash, which is common to all fuels, is the unburnt inorganic matter of the coal used in making the coke. The general properties of coke are described by Joseph D. Weeks as follows:

"Industrial cokes differ greatly in their external appearance, their physical character, and their chemical constitution. In external appearance coke may be light gray and bright, or, as it is generally termed, 'silvery,' or of 'metallic lustre,' or it may be dull and black. Occasionally it is iridescent. It is generally rough-surfaced, but sometimes, especially that portion of a charge near the walls of the oven, is smooth and glossy, having the appearance of polished graphite. Sometimes, also, hair-like threads are observed on masses of ordinary coke.

"In its physical structure it may be porous and light, or compact, dense, and heavy; hard and capable of sustaining a high crushing and compressive strain or load, or soft and brittle, with a low crushing point and compressive strength. Its 'ring' or sound when struck is in some samples almost metallic, and in others dull and heavy. Its degree of combustibility, as well as its ease of ignition, also varies.

"The terms 'dense' and 'hard,' as applied to coke, have a special meaning that should be carefully noted. All coke is more or less cellular in its structure. The less the cell space the denser the coke; the greater the cell space the more porous; that is, 'dense' and 'porous' are opposite conditions. Hard is a term properly applied to the cell walls of the coke, and not to the cell space, and coke is hard or soft as the cell walls are hard or soft. Coke may therefore be very dense and not hard; that is, its cell space may be small and the walls of the cells weak, or it may be porous and hard, or its cell space may be large and the walls hard and strong. Physically, the typical coke for blast-furnace use should be bright silvery, hard, and porous, with a metallic ring; and some of these conditions of physical structure are of more importance in determining its value than has been generally apprehended, and are deserving of more careful consideration than has usually been given them. It is no doubt important that the amount of certain of the chemical constituents of coke should be as high, and of others as low, as possible; but it is equally true that for certain purposes, for iron smelting, for example, unless certain physical conditions exist, the coke is comparatively useless. The content of carbon may be the highest and of ash and sulphur and volatile matter the lowest; but if the coke is soft and brittle its value as a furnace fuel is very small. A dense coke, or one with a small amount of cell space, other things being equal, is within certain limits inferior to one that is porous or with considerable cell space; while a hard coke, or one in which the walls of the cells are hard and strong, is superior to one in which the cell walls are brittle and weak."

The manufacture of coke in the United States is of very recent date, the census of 1850 showing a total amount in value of only $15,000. Prior to this small quantities of coke were made for refining iron, all in Pennsylvania. In 1870 the manufacture of coke is reported in Ohio, and in 1880 nine States made reports of coke manufactured within their respective territories,—viz., Alabama, Colorado, Georgia, Illinois, Indiana, Ohio, Pennsylvania, Tennessee, and West Virginia. In 1902 the coke tonnage of this country was manufactured in twenty-five States and had increased to 69,000 ovens, with a production of 25,400,000 net tons of coke.

By far the largest part of the coal used for coking in the United States comes from three seams,—the Pittsburgh seam in Pennsylvania, the Pottsville conglomerate in the New River and Flat Top districts of Virginia and West Virginia, and the Pratt seam of Alabama. The coal used in making Connellsville coke is from the Pittsburgh seam, locally known as the Connellsville seam. In many parts of the country the slack or fine coal only is used for producing coke, and the general form of oven used is known as the "beehive" pattern. But in the Connellsville region the run-of-mine coal is put directly into the ovens without any preparation or screening, and its conversion into coke is as follows:

"After the coal is mined the process of coking is about the same as adopted in all parts of this country. The coal is brought to the ovens in wagons or cars called 'larries,' which discharge their contents by means of a chute into the ovens. The charge is about six tons of coal. After charging, the door is bricked up and plastered with clay. The heat retained from the previous charge, and also obtained from the alternate ovens, which are in blast, causes the distillation of gases, and these gases pass off through the top of

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the oven. The coal is allowed to bake in the oven for 48 hours, and at the end of that time the mass is thoroughly coked. The finished condition is easily ascertained by looking into the oven over the top of the door. A man then takes a long, hooked pole and tears down the clay and brick from the door. This done he inserts a piece of gas pipe attached to a hose and plays water upon the fire until it is quenched. The coke is then allowed to stand until the water is all driven off as steam. After the oven has been watered and the coke allowed to dry, the coke is drawn out with a scraper, a long iron bar with a hook on its end. It is then forked into wheelbarrows and wheeled across the yard, where it is loaded into cars.

"The method of charging the ovens is as follows: An oven is charged to-day and will be ready for drawing the day after to-morrow. For instance, an oven charged on Monday would be ready to draw on Wednesday; an oven charged on Tuesday would be drawn on Thursday; an oven charged on Friday must necessarily go over to Monday, and that is when 72-hour coke results. After drawing, the heat is kept in the oven to help ignition on recharging. The fuel begins to burn and the coal starts to coke from the top downward. This is proved by the fact that if an oven charged to-day was by accident drawn to-morrow, a charge of coal would be found in the bottom. If the oven is allowed to stand after the air has been admitted without the coke being taken out, it is soon consumed and burns to ashes from the top of the charge downward. Seventy-two-hour coke is always made when there is one day laid off between charging and drawing. A Friday or Saturday oven is therefore increased in the amount of coal charged, which entails a longer burning."

The mountain cokes of Pennsylvania are made in the same manner, but the coal is first screened, the lumps sent to market, and the fine coal only is used for charging the ovens.

CHAPTER XXXII.

BY-PRODUCTS.

MUCH attention has been given lately to a coking process by which the by-products are saved and the gas, tar, and ammonia are utilized instead of being wasted, as is the case when coking is done in the common bee-hive ovens.

The ovens are called "flue-ovens," and are built 18, 20, and 25 feet long in parallel rows. Two of these plants are in operation at Johnstown and Dunbar in Pennsylvania, and one in Syracuse, New York, the plant at Syracuse being chiefly for collecting ammonia for use in the Solvay or ammonia process of soda-making. In this process coals other than high-grade coking coals can be used with good results, the yield of coke being as high as 84 per cent. as against about 64 per cent. from the bee-hive ovens.

The plant at Dunbar, Pennsylvania, is described as follows:

"Ground was first broken for the erection of these ovens in July, 1895. The introduction of the by-product oven into the Connellsville region is being watched with more than ordinary interest by iron manufacturers all over the country. The value and extent of the production of coke in the Connellsville region, which is the largest in the United States, and its importance as a factor in the manufacturing industries of the country, also make the erection of the retorts at Dunbar especially interesting.

"The essential point of a retort oven is the coking of coal in air-tight chambers. The ovens are built in a rectangular form, the retorts being above the foundations of the ovens. The ovens will be charged at the top by three larries and the coal will be burned 24 hours, one-half the time required by the common bee-hive ovens. The coal in the common ovens is burned from the inside, while that in the new process ovens is burned from gas on the outside. On each side of the ovens are three horizontal flues, running the entire length and containing gas, which heats the ovens. The flues are made of tile and are not more than two inches thick, so that the heat can easily be conveyed through. Although the walls are very thin, they are noted for their great durability, lasting, it is claimed, over ten years. Plants of the Semet-Solvay ovens have been in operation eight years without showing any need of repairs in the lining flues. When these flues require replacing, the cost is not over $300 per oven.

"The foundation and whole superstructure enclosing the flues will last as long as any permanent masonry work. The gas in the horizontal flues that are used to heat the ovens is taken from the other ovens that have been burned. One oven is drawn every two hours, and the waste heat is saved in boilers, which are placed between two rows of ovens. The gas from the ovens goes to the by-product house, and is there washed and scrubbed and the by-products obtained. In every ton of coal there are 10,000 cubic feet of gas, 7000 feet of which are used for heating the ovens, the remainder being clear profit. The combustible materials go to the stack through the boilers and make all the steam for the plant. After the coal has been burned under this process for 24 hours the coke is drawn out. The coke ovens can be opened at both ends, and the coke will be pushed out by an engine, which will run along the end of the ovens. The coke will be forced out in a few minutes, and then drenched and cooled on the yards, and hauled to the yards at the furnace.

"As two ovens are drawn every hour, the works will be in operation with very little manual labor used. It is estimated that 200 tons of coke will be made per day by the 50 ovens, 80 per cent. of the coal charged being obtained as coke. At the common bee-hive ovens only 60 per cent. of the coal charged is obtained as coke, not mentioning the loss of the by-products.

" With the Semet-Solvay by-product coke ovens the value of the by-products is such that one could purchase coal, manufacture it into coke, give the coke away, and make a handsome profit from the sale of the by-products. Besides the increased yield of coke per ton, which is a clear profit to the coke-maker, there is an independent source of profit from the by-products, which may be considered as a somewhat separate business, involving various chemical operations. The cost of obtaining these materials will depend upon the skill and economy with which the by-product saving apparatus is operated.

" 'In every ton of coal 3000 cubic feet of gas will be obtained after the necessary supply is used to operate the ovens. This gas can be used either for illuminating or heating purposes, and will furnish from 14 to 20 candle-power light. It is four times as strong in heat as producer gas. It is estimated that the 50 coke ovens can supply the entire town of Dunbar and vicinity for heating purposes, as there will be between 50,000 and 60,000 cubic feet produced each day.

" 'The cost of the by-product oven is three or four times as much as the bee-hive oven, but the former lasts two or three times as long, as the quenching of the coke is done on the outside, while in the latter the coke is watered while hot in the ovens, thus injuring, to some degree, the material of the oven. The increased yield is, therefore, an actual profit, independent of the by-products. This system of coke manufacture is by no means a new thing, although of recent introduction in this country. The continent of Europe has practically abandoned the bee-hive ovens. In Germany, Belgium, and France there are only a few isolated bee-hive ovens in operation. England, more conservative, has clung obstinately to the bee-hive oven, although her supremacy in the iron trade is passing away.

" 'Sir Lowthian Bell is largely responsible for the opposition of English ironmasters to by-product ovens, but he has recently expressed an opinion that in view of the improvements in retort oven practice he might have to modify his adverse report upon them. In this country we have pursued the wasteful methods of fifty years ago. The coking regions burn up millions of dollars' worth of valuable gases, illuminating the country for miles around. The coke made in this reckless manner is of less market value than the wasted by-products. This has caused our iron industry to suffer years of depression, even when every improvement in the blast furnace has been courageously adopted.

" 'The last step to cheapen iron is the by-product coke oven. Two general types of retort coke ovens have been developed, the one chiefly represented by the Otto-Hoffman form, with vertical flues and regenerative firing, and the other by the Semet-Solvay form, with horizontal flues and continuous reception of heat. The former has for about fifteen years been in use in Europe, and under the exploitation of one of the leading fire-brick manufacturers of Germany has attained wide development. The erroneous principle, however, of applying the expensive system of the Siemens regenerator to a fuel operation requiring only the moderate heat of the coke oven has long been manifest, and has now been demonstrated in the simpler methods of continuous recuperation in the Semet-Solvay ovens. Either of these two types of ovens gives a great increase in the value of the products obtained from a ton of coal as compared with the yield from the bee-hive ovens.' "

Efforts are also being made to use coke as a locomotive fuel. In 1884 the first experiments were made in this direction when coke was used on the fast express trains of the Baltimore and Ohio Railroad running between Washington and Philadelphia. Coke produces practically no smoke, but it gives out a penetrating gas under certain conditions of draft and air supply. A great deal of difficulty was found at first in educating the men to fire this fuel properly, and it is reported that only after about a year and a half did they acquire sufficient experience to handle it without difficulty. A coke fire requires special care and far more attention than one of coal, and on this account the fuel does not find much favor with firemen, who, as a rule, dislike it.

"In the fire, coke gives a very intense local heat and must be fired heavily. The green coke is massed at the door and gradually worked forward into the fire. No deleterious effects are found in the use of coke as to action on the fire-boxes, even after a continued experience covering five years, which is ample time for a perfectly satisfactory trial.

"Some difficulty has been experienced on account of a deposit of solid matter from the coke which limits the length of the run with this fuel to about 100 miles. The deposit is formed on the flue sheets and also on the netting in the front end, and at the end of about the distance stated this becomes sufficient in amount to interfere with the draft and the steaming of the engine unless handled with great care. As to its efficiency as a fuel, it is reported that about 10 per cent. better evaporative results may be obtained from coke than from an equal weight of bituminous coal such as is used on the Baltimore and Ohio Railroad. There is a great difference in the volumes of coal and coke, weight for weight, which necessitates the construction of special racks upon the tenders in order to carry sufficient fuel for long runs. The average cost of coal on four divisions in 1894 was $1.09, and the average cost of coke for the same divisions was $1.85, which gives a general idea of the relative costs of the two fuels. This ratio, however, is somewhat affected by the cost of hauling from the mines and ovens. In spite of the fact that better results are obtained from coke than from equal weights of coal, the former remains a very much more expensive fuel, and its use will probably be determined only by such factors as comfort of passengers and freedom from smoke in large cities. It is the practice on the Baltimore and Ohio Railroad to mix some coal with the coke in the proportions of about one-tenth of coal to nine-tenths of coke. This is done in places where coke alone cannot be used, and the smoke produced is in proportion to the ratio of coal to coke. It may be said that the results of the use of coke are fairly good from a standpoint of economical working, yet it is unquestionable that the reason for its employment is merely that of the comfort of patrons of the roads and the reduction of smoke."

The improved methods of coking bituminous coal add a step in the progress we are making towards gaseous fuels and the utilization of the vast bituminous coal-fields of our country, the source to which we must turn for our fuel supply when in the near future our anthracite fields become exhausted; a never-failing source from which we have drawn our coal and increased our wealth as no other nation has done since coal was first discovered.

CHAPTER XXXIII.

CONCLUSION.

When we review the preceding pages the most astonishing fact presented to our notice is the wonderful growth of our coal tonnage in so short a period of time.

In sixty years the United States has advanced in the production of coal from 3,000,000 tons in 1845 to 300,000,000 tons in 1904, thus fulfilling the many predictions made at a time when our insignificant tonnage would scarcely have seemed to warrant them. The material increase has been made in even less time. In 1866 our total production of coal was "less than 15,000,000 tons," while in the same year Great Britain produced 100,000,000 tons; but at that time the prediction was made by L. Simonin: "America with her immense coal-fields is destined to become eventually the great coal-producer of the world."

Instead of sixty, we therefore have thirty years as nearer the actual time in which this remarkable coal development in our country has taken place. This coal has practically all been consumed at home and without invading "the markets of the world."

I have prepared the following table from various sources, showing the world's progress in the development of coal during the same period:

United States	301,500,000
Great Britain	254,300,000
Germany	165,800,000
Austria-Hungary	45,400,000
France	33,200,000
Belgium	24,500,000
Russia	18,000,000
Japan	8,300,000
India	8,200,000
Canada	7,600,000
New South Wales	6,600,000
Spain	3,000,000
New Zealand	1,300,000
South African Republic	700,000
Queensland	560,000
Italy	470,000
Sweden	335,000
Victoria	235,000
Net tons	880,000,000

From the foregoing it will be seen that the United States stands well ahead of all other countries in coal production and has passed our most formidable rival, Great Britain, with tonnage to spare. If we add the coal production of all her colonies and dependencies to Great Britain's total we are still ahead by a comfortable margin. This lead will be maintained from now on. *The United States will never again take second place in coal development.*

A brief study of the foregoing figures will emphasize the conclusion:

"*The most polished nations cannot for the future dispense with coal, and the degree of a country's civilization may almost be estimated by the quantity of this combustible which it consumes.*"

At the front of all the coal-producing nations is the United States, with Great Britain next. We now stand at the head of all other countries as a producer of coal and what it signifies,—Power.

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